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SHELTER UPGRADING MANUAL: HOST AREA SHELTERS, REVISIONS AND ADD--ETC(U)
MAY 81 C WILTON, B L GABRIELSEN, R S TANSLEY EMM-C-0153

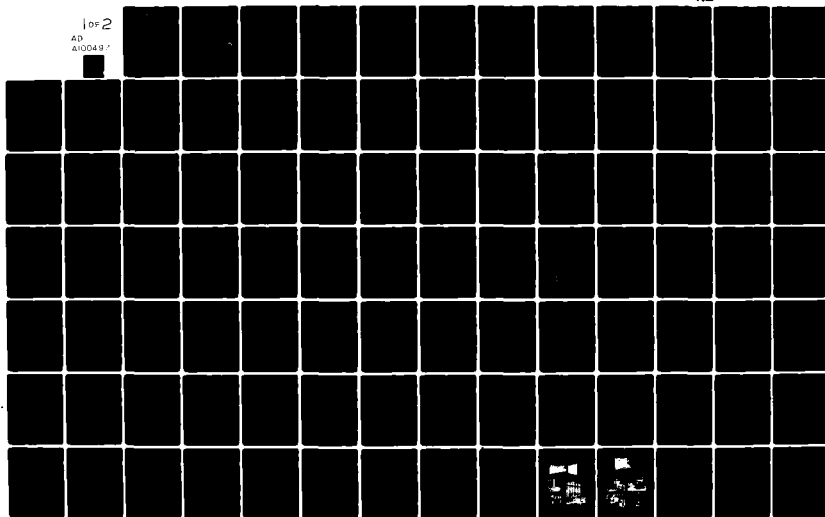
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May 1981

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REVISIONS AND ADDITIONS

to

Shelter Upgrading Manual: Host Area Shelters

by

C. Wilton, B.L. Gabrielsen, and R.S. Tansley

for

Federal Emergency Management Agency
Washington, D.C. 20472

Contract No. EMW-C-0153, Work Unit 1128A
(originally Work Unit 1127H)
Dr. Michael A. Pachuta, Project Officer

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Shelter Upgrading Manual: Host Area Shelters, which was originally developed under Contract No. DCPA01-78-C-0215, Work Unit 1127H, is in looseleaf form to permit removal of pertinent worksheets and charts for developing upgrading plans for a specific building and to permit the addition of new and replacement material as the work progresses. The manual is one of a series being developed in support of the civil		

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Block 20. Abstract (contd)

defense concept of crisis relocation planning and is designed to be used by planners in host areas. It presents a methodology for evaluating floors, roofs, and openings and develops a variety of ways to provide the necessary structural upgrading for blast and fallout protection.

The revisions included here are based on a testing program and are generally in the area of modified survival ratings. Additional new material on expedient shelters is included in an appendix.

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SHELTER UPGRADING MANUAL: HOST AREA SHELTERS

Revisions and Additions

The Shelter Upgrading Manual: Host Area Shelters, SSI Report No. 7815-8, which was first published in March 1980, has been revised and updated. The enclosed packet of materials contains revisions of existing pages and some additional new pages.

Please make the following changes in your copy of that report:

Page

iii/iv	Replace
1-1/1-2	Replace (page 1-1 revised)
2-5/2-6	Replace (page 2-5 revised)
2-7/2-8	Replace (page 2-8 revised)

Section 4

Index/chart	Replace (revisions to both sides)
4-1/chart	Replace (chart on reverse side revised)
4-2/chart	Replace (chart on reverse side revised)
4-3/chart	Replace (page 4-3 revised)
4-4/chart	Replace (page 4-4 revised)
4-5/chart	Replace (chart on reverse side revised)
4-6/chart	Replace (chart on reverse side revised)
4-16/chart	Replace (<u>new</u> chart on reverse side)
4-16a/chart	<u>Add new page</u>
4-22/chart	Replace (<u>new</u> chart on reverse side)
4-22a/chart	<u>Add new page</u>
4-28/chart	Replace (<u>new</u> chart on reverse side)
4-29	<u>Add new page</u>

Revisions and Additions to SHELTER UPGRADING MANUAL: HOST AREA SHELTERS
(continued)

Page

Section 5

Index/chart	Replace (both sides revised)
5-1/chart	Replace (chart on reverse side revised)
5-2/chart	Replace (chart on reverse side revised)
5-10/chart	Replace (<u>new</u> chart on reverse side)
5-11	<u>Add new page</u>

Section 6

Index/resource list	Replace (index revised)
6-9/resource list	Replace (page 6-9 revised)
6-10/resource list	Replace (page 6-10 revised)
6-20a/resource list	<u>Add new page</u>
6-20b/resource list	<u>Add new page</u>
6-39/resource list	Replace (<u>new</u> resource list on reverse side)
6-40/resources list	<u>Add new page</u>
6-41	<u>Add new page</u>

Appendix B

B-1/B-2	Replace (page B-1 revised)
B-11 to B-17	<u>Add new pages</u>

Appendix D

D-1 to D-32	<u>Add new Appendix</u>
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Glossary and List of Notations

As built —	Structure prior to upgrading	psf	pounds per square foot
Host area —	Area that is subjected to blast pressures of 2 psi or less	psi	pounds per square inch
Key worker area —	Area that is subjected to blast pressures greater than 30 psi	kPa	kilopascal (psi times 6.895)
Overpressure —	Pressure caused by blast	S_R	survival rating
Protection factor —	Factor that compares degree of radiation protection to zero protection	P_f	protection factor
Protection factor key —	Earth thickness in feet required to obtain specified radiation protection	I	shelter rating - 40 psi overpressure
Risk area —	Area that is subjected to blast pressures from 2 psi to 30 psi	II	shelter rating - 30 psi overpressure
Shelter rating —	Rating given a shelter, in roman numerals, corresponding to a given overpressure (see Fig. 1-1)	III	shelter rating - 20 psi overpressure
Survival rating —	95% probability of survival for a structure of a given shelter rating	IV	shelter rating - 10 psi overpressure
		V	shelter rating - 5 psi overpressure
		VI	shelter rating - 2 psi overpressure
		VI ⁺	slightly better than a VI shelter rating (used for all shelter ratings)
		VI ⁻	slightly less than a VI shelter rating (used for all shelter ratings)
		N	no additional radiation protection required
		"0"	provides no blast survival
		+	depth of earth required for radiation protection would cause collapse

Section 1 INTRODUCTION

This manual is intended for use in the identification of and the upgrading, if required, of shelter spaces to support Crisis Relocation Planning. Concern is limited here to shelters in the "host" areas, where it is assumed blast overpressures do not exceed 2 psi and radiation protection equivalent to 18 in. of earth is adequate.

The manual is organized as follows: Section 2 will assist in the selection and identification of potential shelter facilities. Section 3 explains the use of the manual and the selection of methods for upgrading with examples. Sections 4 and 5 contain the key charts on the upgrading of various floors and roofs. Section 6 contains sketches of the various upgrading methods and the resources required for each. Section 7 has the various worksheets for each method. Section 8 includes the charts necessary for sizing the shoring required for the upgrading method selected. At the end of the manual, appendices containing supplemental information are provided. Appendix A assists in the evaluation of a structure for use as a potential shelter. Appendix B provides data and charts for closing small openings. Appendix C illustrates alternative types of shoring systems. Appendix D covers expedient shelter options.

The manual is in looseleaf format for two reasons: (1) Use of the manual requires that worksheets and data sheets be removed to develop upgrading plans for a specific building; and (2) In its present form the manual is far from complete, and replacement or new pages and sections, which are being developed by SSI, will be supplied for insertion when available. Included in this new information will be additional upgrading schemes for floors and roofs, based on upcoming full-scale tests of floor and roof systems;

procedures for upgrading walls of aboveground shelters; a more extensive closure section; and the necessary information for calculating required supplemental equipment such as ventilation, water and sanitation kits.

It should also be noted that the manual is one of a series that will also consider key worker and risk area shelters. In these other manuals higher overpressures will be considered, and shelters will be ranked by survival ratings "as built" and for the various upgrading schemes. Shelters will be rated for selected overpressures, and each shelter rating will carry a roman numeral designation corresponding to a particular overpressure. A pictorial representation of the relationship between shelter rating, overpressure, and the key worker, risk, and host areas is shown in Fig. 1-1. As mentioned above, this manual confines itself to VI shelter rating or a maximum of 2 psi overpressure, which is defined as a host area shelter.

Table 2-2

FLOOR SYSTEM COLLAPSE LOADS ⁽¹⁾ psf (psi)

Floor Type and Dead Load (D.L.)	Live Load		
	LIGHT (L) 50 psf (40 - 60 psf)	MEDIUM (M) 100 psf (80 - 125 psf)	HEAVY (H) 200 psf (150 - 250 psf)
Wood (W) Construction (D.L. = 20 psf)	92 (0.6) soil ⁽²⁾ 155 (1.1) blast ⁽³⁾	172 (1.2) soil ⁽²⁾ 280 (1.9) blast ⁽³⁾	332 (2.3) soil ⁽²⁾ 530 (3.7) blast ⁽³⁾
Steel, Light (SL) Construction (D.L. = 30)	105 (0.7)	190 (1.3)	does not exist
Steel, Heavy (SH) Construction (D.L. = 80)	140 (1.0)	225 (1.6)	395 (2.8)
Concrete (C) Construction (D.L. = 100)	200 (1.4)	300 (2.1)	500 (3.5)

Notes

- (1) Load increase factors are 1.7 for steel, and 2.0 for concrete, respectively. The 1.7 for steel assumes a truss support system.
- (2) Load increase factor for static load (soil) for timber is 1.6.
- (3) Load increase factor for dynamic load (blast) for timber is 2.5.

Table 2-3
FLOOR SAFETY RATING TABLE FOR AS BUILT CONSTRUCTIONS
WITH $P_f = 100$ (18 in. soil) AND $S_R = VI$ (2 psi)

Type \ Loading	Light 50 psf (40 - 60 psf)	Medium 100 psf (80 - 125 psf)	Heavy 200 psf (150 - 250 psf)
Wood Construction	Upgrading required, see Section 3	Upgrading required, see Section 3	"OK" as built
Steel Light Construction	Upgrading required, see Section 3	Upgrading required, see Section 3	Does not exist
Steel Heavy Construction	Upgrading required, see Section 3	Upgrading required, see Section 3	"OK" as built
Concrete Construction	Upgrading required, see Section 3	Upgrading required, see Section 3	"OK" as built

ROOF SYSTEM ANALYSIS

A similar analysis can be applied to roof systems. It is assumed that the roof systems of interest are relatively flat and that the radiation upgrading can be accomplished by adding soil. Table 2-4 provides the results of the analysis in force units.

There are no roof systems that, without upgrading, will have an $S_R = VI$ (2 psi plus 18 in. soil).

Refer directly to Section 3 of the manual for the appropriate methods of upgrading.

Table 2-4
ROOF SYSTEM ANALYSIS

Column 1	Column 2	Column 3	Column 4	Column 5
Roof Type	Design Live Load	Design Dead Load	Load Increase Factor	Collapse ⁽⁴⁾ Load ⁽⁵⁾
	psf	psf	psf	psf (psi)
Wood (W)	15	15	1.6 2.5	33 (0.2) soil 60 (0.4) blast
Steel ⁽¹⁾ (SL) Light Con- struction	15	25	1.7 ⁽³⁾	45 (0.3) soil or blast
Steel ⁽²⁾ (SH) Heavy Con- struction	15	60	1.7 ⁽³⁾	65 (0.4) soil or blast
Concrete (C)	15	80	2.0	110 (0.8) soil or blast

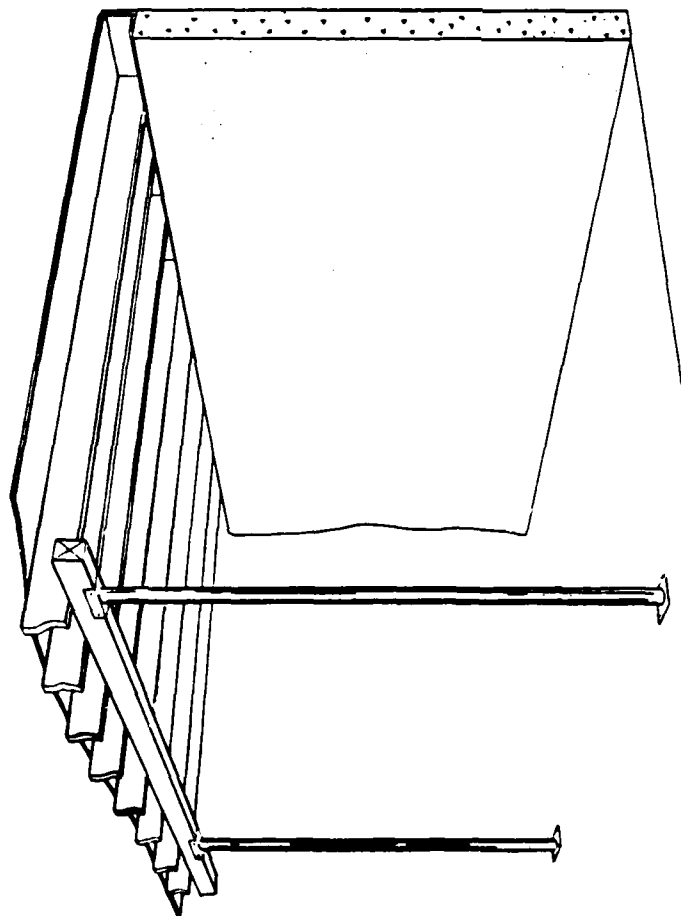
Notes

- (1) Light steel construction assumes a steel support structure and a timber sheathing system.
- (2) Heavy steel construction assumes a steel support structure, steel decking and a lightweight concrete topping.
- (3) The 1.7 load increase factor assumes truss supports. Beams will provide a higher load increase factor.
- (4) The collapse load values shown in Column 5 can be increased in snow regions by multiplying the regional design snow load minus 15 psf by the safety factor and adding to Column 5.
- (5) If a roof structure is used for parking or some other activity, analyze it as a floor system.

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WOOD CONSTRUCTION - FLOOR				SURVIVAL RATING VI		
TIMBER JOIST-LIGHT DESIGN				SUPERIMPOSED DESIGN LOAD-40 to 60 PSF		
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7
Wood Stud Wall at Midspan	40 100 1000	1 1.5 3	VI ⁺ VI 0	Page 6-1	Page 8-1	Page 7-1
Post and Beam Shores at Mid- span	40 100 1000	1 1.5 3	VI ⁺ VI 0	Page 6-2	Page 8-2, 8-3	Page 7-2
King Post Truss	40 100 1000	1 1.5 3	VI 0 +	Page 6-3		Page 7-3
Flange	40 100 1000	1 1.5 3	VI ⁻ 0 +	Page 6-4		Page 7-4
Boxed Beam	40 100 1000	1 1.5 3	VI ⁻ 0 +	Page 6-5		Page 7-5



TYPICALLY FOUND IN RESIDENTIAL BASEMENTS AND SMALL COMMERCIAL BUILDINGS.

SPANS NORMALLY 6 FT TO 18 FT, DEPTH OF JOIST 6 IN. TO 12 IN.

SUPPORT BEAM CAN BE EITHER STEEL OR WOOD, AND SUPPORT POSTS WOOD OR STEEL PIPE.

DESIGN CRITERION 40 - 60 PSF.

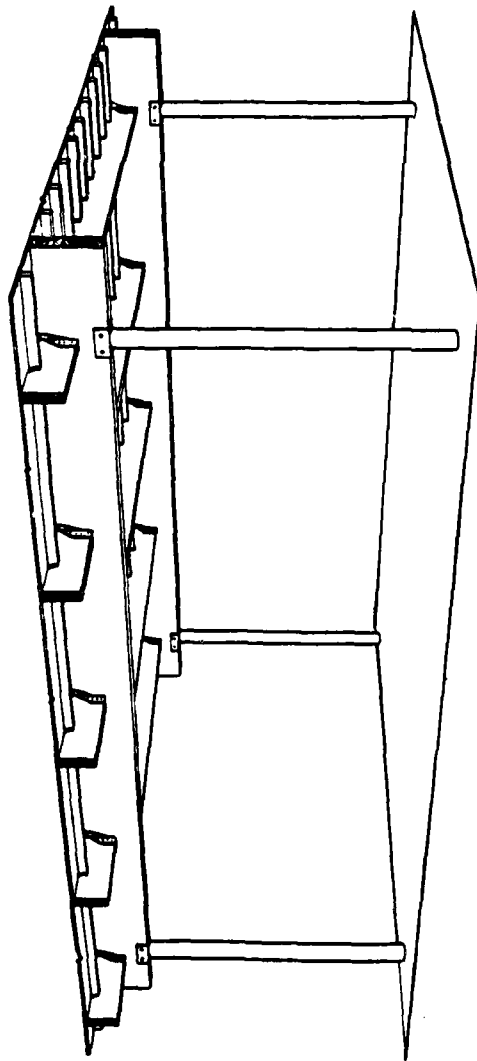
RADIATION		SURVIVAL RATING
Pf	KEY	
40	1	0
100	1.5	+
1000	-	-

WOOD CONSTRUCTION - Floors

TIMBER JOIST - Light Design

AS BUILT

WOOD CONSTRUCTION - FLOOR					SURVIVAL RATING VI		
GLULAM-LIGHT DESIGN					SUPERIMPOSED DESIGN LOAD-40 to 60 PSF		
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7	
Wood Stud Wall at Midspan	40	1	VI ⁺	Page 6-6	Page 8-1	Page 7-1	
	100	1.5	VI				
	1000	3	0				
Post and Beam Shores at Mid- span	40	1	VI ⁺	Page 6-7	Page 8-2, 8-3	Page 7-2	
	100	1.5	VI				
	1000	3	0				
King Post Truss	40	1	VI	Page 6-8		Page 7-3	
	100	1.5	0				
	1000	3	+				



TYPICALLY FOUND IN SMALL
COMMERCIAL BUILDINGS,

SPANS NORMALLY 6 FT TO
18 FT, DEPTH OF GLULAM
JOIST 4 IN. TO 8 IN.,
SUPPORTED ON GLULAM BEAM,
NORMALLY 8 IN. TO 16 IN.
DEEP.

SUPPORT POSTS WOOD OR STEEL
PIPE.

DESIGN CRITERION 40 - 60 PSF

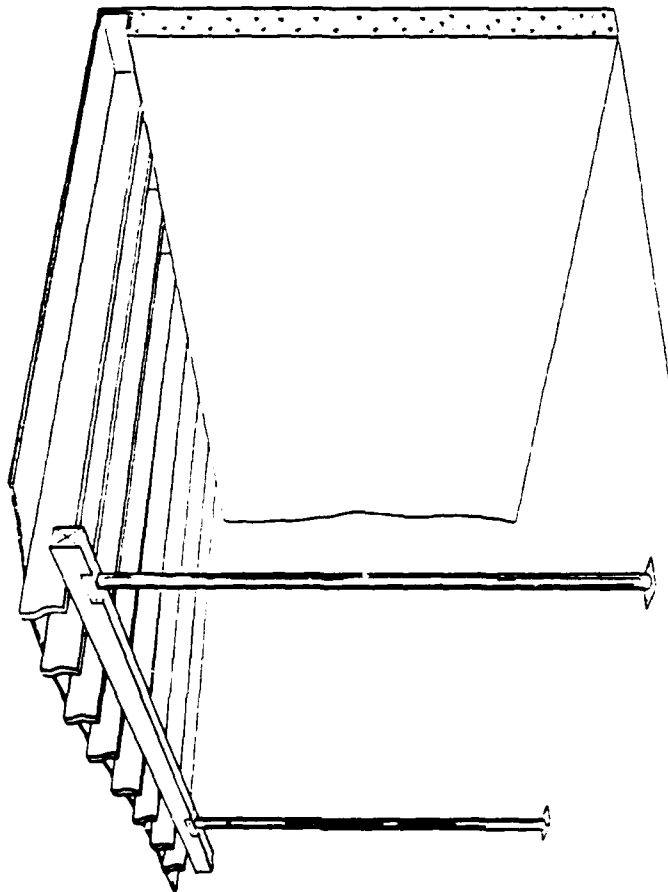
RADIATION		SURVIVAL RATING
Pf	KEY	
40	1	0
100	1.5	+
1000	-	-

WOOD CONSTRUCTION—Floors

GLULAM — Light Design

AS BUILT

WOOD CONSTRUCTION - FLOOR				SURVIVAL RATING VI		
TIMBER JOIST-MEDIUM DESIGN				SUPERIMPOSED DESIGN LOAD-80 to 125 PSF		
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7
Wood Stud Wall at Midspan	40	1	VI ⁺	Page 6-1	Page 8-1	Page 7-1
	100	1.5	VI			
	1000	3	0			
Post and Beam Shores at Mid- span	40	1	VI ⁺	Page 6-2	Page 8-2, 8-3	Page 7-2
	100	1.5	VI			
	1000	3	0			
King Post Truss	40	1	VI ⁺	Page 6-3		Page 7-3
	100	1.5	VI ⁺			
	1000	3	VI ⁺			
Flange	40	1	VI ⁺	Page 6-4		Page 7-4
	100	1.5	VI ⁺			
	1000	3	VI			
Boxed Beam	40	1	VI ⁺	Page 6-5		Page 7-5
	100	1.5	VI ⁺			
	1000	3	VI			



TYPICALLY FOUND IN RETAIL STORES
AND LIGHT MANUFACTURING BUILDINGS.
SPANS NORMALLY 6 FT TO 18 FT,
DEPTH OF JOIST 6 IN. TO 12 IN.
SUPPORT BEAM CAN BE EITHER STEEL
OR WOOD, AND SUPPORT POSTS, WOOD
OR STEEL PIPE.
DESIGN CRITERION 80 TO 125 PSF

RADIATION		SURVIVAL RATING
Pf	KEY	
40	1	0
100	1.5	0
1000	3	+

WOOD CONSTRUCTION—Floors

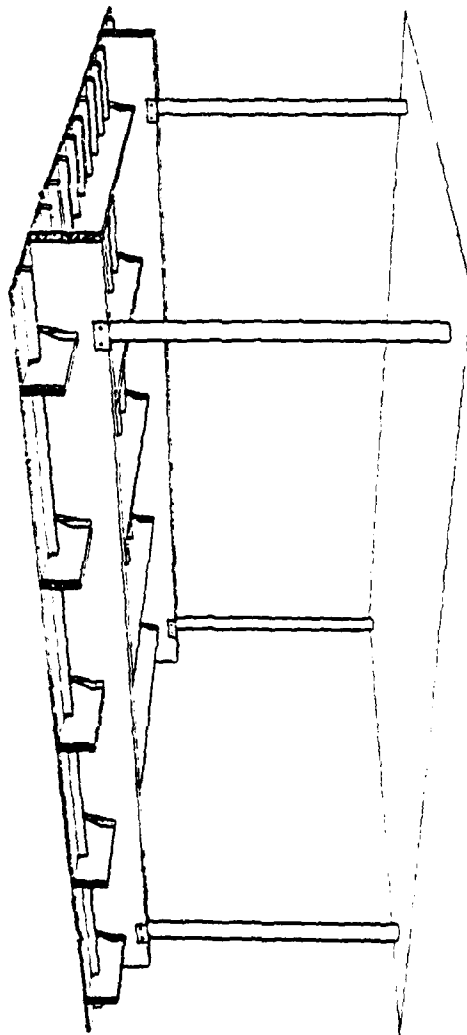
TIMBER JOIST—Medium Design

Revised - 5/81

4-3

AS BUILT

WOOD CONSTRUCTION - FLOOR				SURVIVAL RATING VI		
GLULAM-MEDIUM DESIGN				SUPERIMPOSED DESIGN LOAD -80 to 125 PSF		
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7
Wood Stud Wall at Midspan	40	1	VI ⁺	Page 6-6	Page 8-1	Page 7-1
	100	1.5	VI			
	1000	3	0			
Post and Beam Shores at Mid- span	40	1	VI ⁺	Page 6-7	Page 8-2, 8-3	Page 7-2
	100	1.5	VI			
	1000	3	0			
King Post Truss	40	i	VI ⁺	Page 6-8		Page 7-3
	100	1.5	VI ⁺			
	1000	3	VI ⁺			



TYPICALLY FOUND IN RETAIL STORES AND LIGHT MANUFACTURING BUILDINGS.

SPANS NORMALLY 6 FT TO 18 FT, DEPTH OF GLULAM JOIST, 6 IN. TO 8 IN., SUPPORTED ON GLULAM BEAM, NORMALLY 8 IN. TO 16 IN. DEEP.

SUPPORT POSTS WOOD OR STEEL PIPE.

DESIGN CRITERION 80 - 125 PSF.

RADIATION		SURVIVAL
P _F	KEY	RATING
40	1	0
100	1.5	0
1000	-	+

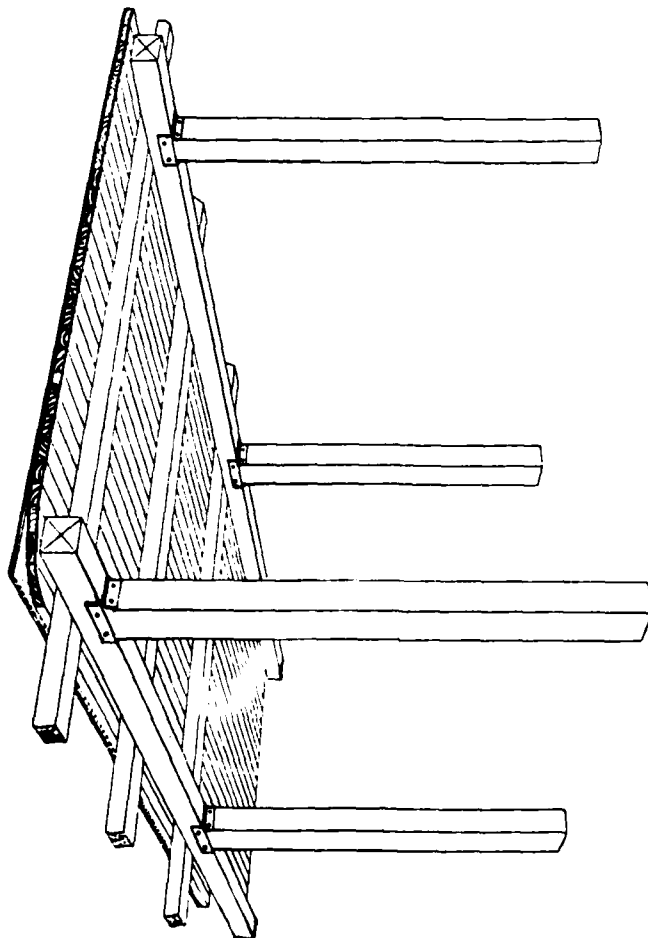
WOOD CONSTRUCTION--Floors GLULAM -- Medium Design

Revised - 5/81

4-4

AS BUILT

WOOD CONSTRUCTION - FLOOR				SURVIVAL RATING VI		
TIMBER PLANK-HEAVY DESIGN				SUPERIMPOSED DESIGN LOAD 150 to 250 PSF		
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7
None Required	40	1	VI ⁺	<u>DOES NOT REQUIRE UPGRADING</u>		
	100	1.5	VI ⁺			
	1000	3	VI ⁺			



TYPICALLY FOUND IN HEAVY MANUFACTURING BUILDINGS AND STORAGE WAREHOUSES.

SPANS NORMALLY 6 FT TO 18 FT. BEAM MINIMUM 4 IN. BY 4 IN. SIZE, GIRDERS MINIMUM 8 IN. BY 8 IN. SIZE.

PLANK FLOOR MINIMUM 3 IN. TIMBER. COLUMNS USUALLY TIMBER, MINIMUM 8 IN. BY 8 IN.

DESIGN CRITERION 150 - 250 PSF.

RADIATION		SURVIVAL RATING
PF	KEY	
40	1	VI ⁺
100	1.5	VI ⁺
1000	3	VI ⁺

WOOD CONSTRUCTION--Floors

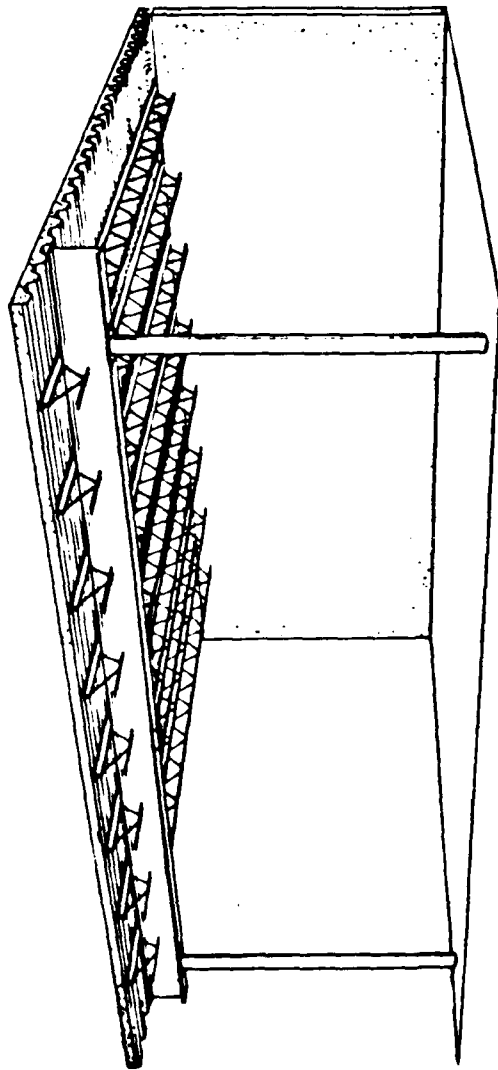
TIMBER PLANK--Heavy Design

4-5

AS BUILT

STEEL - LIGHT CONSTRUCTION - FLOOR				SURVIVAL RATING VI		
OPEN-WEB JOIST - LIGHT DESIGN				SUPERIMPOSED DESIGN LOAD-40 to 60 PSF		
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7
Two rows of Wood Stud Walls, one each at 1/3 span	40	1	VI ⁺	Page 6-9	Page 8-1	Page 7-1
	100	1.5	VI			
	1000	3	0			
Two rows of Post and Beam Shores, one each at 1/3 span	40	1	VI ⁺	Page 6-10	Page 8-2, 8-3	Page 7-2
	100	1.5	VI			
	1000	3	0			

Revised - 5/81



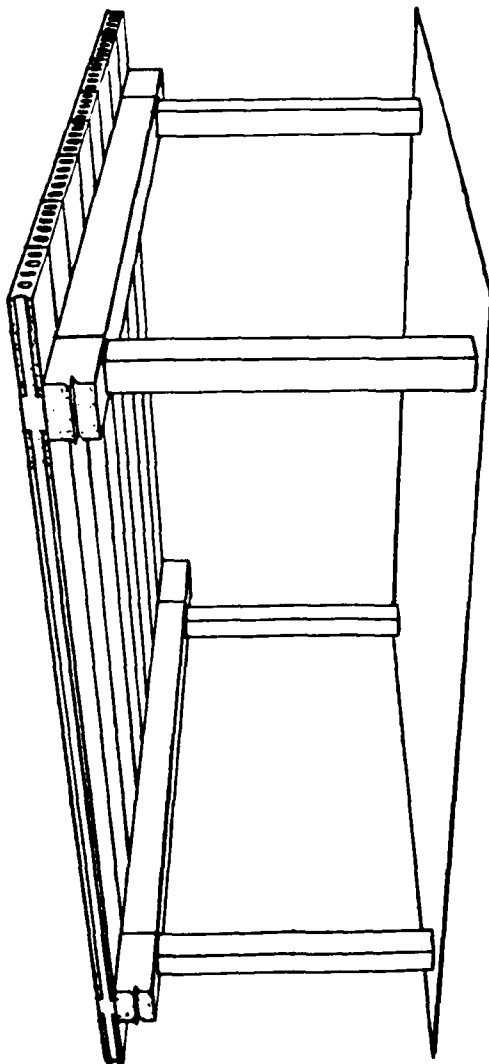
TYPICALLY FOUND IN SMALL
COMMERCIAL BUILDINGS.
SPANS NORMALLY 8 FT TO 26 FT.
OPEN-WEB JOIST DEPTH 8 IN. TO
16 IN.
SUPPORT BEAM NORMALLY STEEL,
DESIGN CRITERION 40 - 60 PSF.

RADIATION		SURVIVAL RATING
Pf	KEY	
40	1	0
100	1.5	+
1000	-	-

STEEL-LIGHT CONSTRUCTION-Floors AS BUILT

OPEN-WEB JOIST-Light Design

STEEL - LIGHT CONSTRUCTION - FLOOR				SURVIVAL RATING VI		
OPEN-WEB JOIST - MEDIUM DESIGN				SUPERIMPOSED DESIGN LOAD-80 to 125 PSF		
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7
Two rows of Wood Stud Walls, one each at 1/3 span	40	1	VI ⁺	Page 6-9	Page 8-1	Page 7-1
	100	1.5	VI			
	1000	3	0			
Two rows of Post and Beam Shores, one each at 1/3 span	40	1	VI ⁺	Page 6-10	Page 8-2, 8-3	Page 7-2
	100	1.5	VI			
	1000	3	0			
King Post Truss	40	1	VI ⁺	Page 6-11		Page 7-3
	100	1.5	VI ⁺			
	1000	3	0			



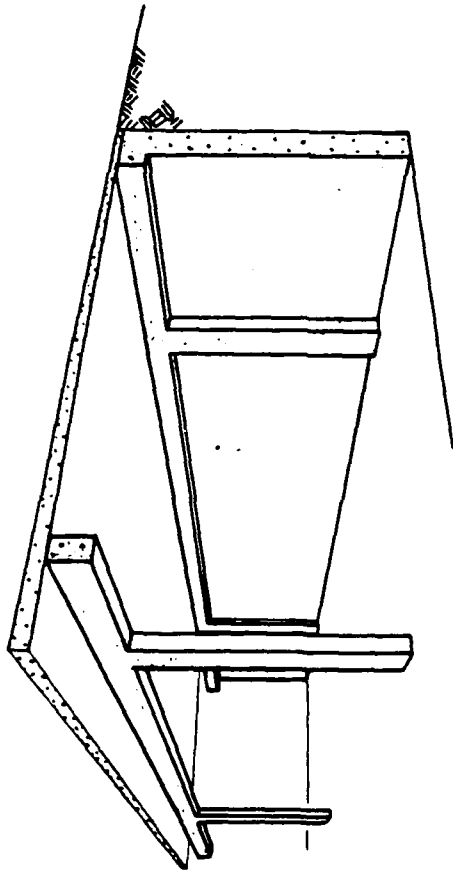
TYPICALLY FOUND IN SMALL
COMMERCIAL BUILDINGS.
SPANS NORMALLY 12 FT TO
34 FT.
SLAB 4 IN. TO 8 IN. THICK.
SUPPORT BEAMS AND COLUMNS
USUALLY CONCRETE.
DESIGN CRITERION 40 TO
60 PSF.

RADIATION		SURVIVAL RATING
PF	KEY	
40	0.5	0
100	1	0
1000	2.5	+

CONCRETE CONSTRUCTION—Floors HOLLOW-CORE — Light Design

AS BUILT

CONCRETE CONSTRUCTION - FLOOR				SURVIVAL RATING VI		
ONE - WAY SLAB - LIGHT DESIGN				SUPERIMPOSED DESIGN LOAD-40 to 60 PSF		
SHORING SYSTEM REQUIRED	P_f	KEY	S_R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7
Wood Stud Wall at Midspan	40	0.5	VI ⁺	Page 6-20A	Page 8-1	Page 7-1
	100	1	VI			
	1000	2.5	0			
Post and Beam Shores at Mid- span	40	0.5	VI ⁺	Page 6- 20B	Page 8-2, 8-3	Page 7-2
	100	1	VI			
	1000	2.5	0			



TYPICALLY FOUND IN SMALL
COMMERCIAL BUILDINGS.
SPANS NORMALLY 10 FT TO
25 FT.
SLAB 5 IN. TO 8 IN. THICK.
SUPPORT BEAMS AND COLUMNS
USUALLY CONCRETE.
DESIGN CRITERION 40 TO
60 PSF.

RADIATION		SURVIVAL RATING
PF	KEY	
40	0.5	0
100	1	0
1000	2.5	+

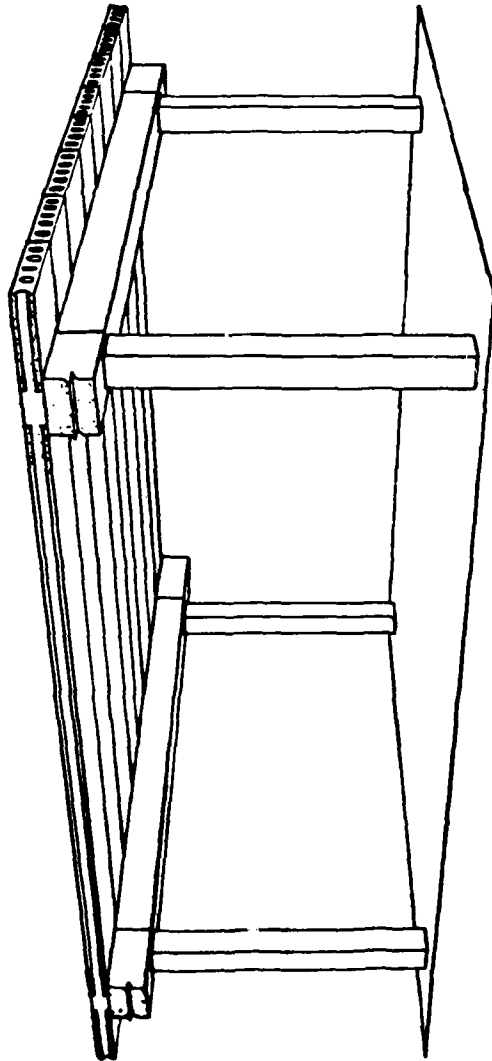
CONCRETE CONSTRUCTION-Floors ONE-WAY SLAB - Light Design

Addition - 5/81

4-16A

AS BUILT

CONCRETE CONSTRUCTION - FLOOR				SURVIVAL RATING VI		
DOUBLE TEES - MEDIUM DESIGN				SUPERIMPOSED DESIGN LOAD- 80 to 125 PSF		
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7
Wood Stud Wall at Midspan	40	0.5	VI ⁺	Page 6-14	Page 8-1	Page 7-1
	100	1	VI			
	1000	2.5	0			
Post and Beam Shores at Mid- span	40	0.5	VI ⁺	Page 6-15	Page 8-2, 8-3	Page 7-2
	100	1	VI			
	1000	2.5	0			



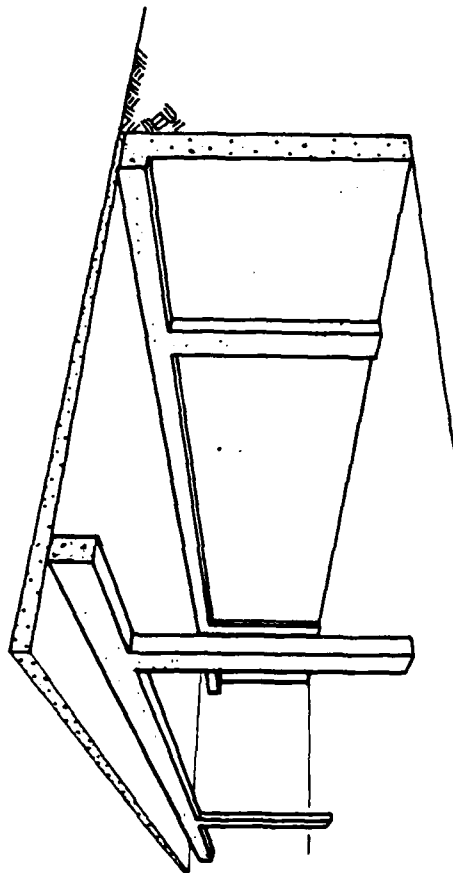
TYPICALLY FOUND IN RETAIL STORES AND LIGHT MANUFACTURING BUILDINGS.
 SPANS NORMALLY 16 FT TO 30 FT.
 SLAB 6 IN. TO 10 IN. THICK.
 SUPPORT BEAMS AND COLUMNS USUALLY CONCRETE.
 DESIGN CRITERION 80 TO 125 PSF.

RADIATION		SURVIVAL RATING
Pf	KEY	
40	0.5	0
100	1	0
1000	2.5	0

CONCRETE CONSTRUCTION—Floors HOLLOW-CORE — Medium Design

AS BUILT

CONCRETE CONSTRUCTION - FLOOR				SURVIVAL RATING VI		
ONE-WAY SLAB - Medium Design				SUPERIMPOSED DESIGN LOAD-80 to125 PSF		
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7
Wood Stud Wall at Midspan	40	0.5	VI ⁺	6-20A	Page 8-1	Page 7-1
	100	1	VI ⁺			
	1000	2:5	0			
Post and Beam Shores at Mid- span	40	0.5	VI ⁺	6-20B	Page 8-2, 8-3	Page 7-2
	100	1	VI ⁺			
	1000	2.5	0			



TYPICALLY FOUND IN RETAIL
STORES AND LIGHT MANUFAC-
TURING BUILDINGS.
SPANS NORMALLY 12 FT TO
30 FT.
SLAB 8 IN. TO 10 IN. THICK.
SUPPORT BEAMS AND COLUMNS
USUALLY CONCRETE.
DESIGN CRITERION 80 TO
125 PSF.

RADIATION		SURVIVAL RATING
Pf	KEY	
40	N	VI
100	0.5	0
1000	2.0	0

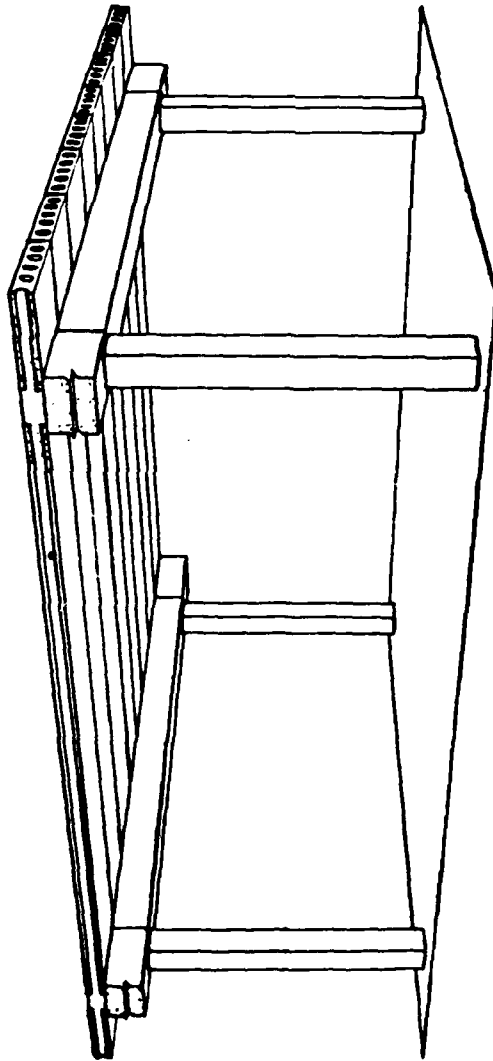
CONCRETE CONSTRUCTION—Floors ONE-WAY SLAB — Medium Design

4-22A

Addition - 5/81

AS BUILT

CONCRETE CONSTRUCTION - FLOOR				SURVIVAL RATING VI		
DOUBLE TEES - HEAVY DESIGN				SUPERIMPOSED DESIGN LOAD-150 to 250 PSF		
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7
None Required	40	0.5	VI ⁺	<u>DOES NOT REQUIRE UPGRADING</u>		
	100	1	VI ⁺			
	1000	2.5	VI			



TYPICALLY FOUND IN HEAVY
MANUFACTURING BUILDINGS
AND STORAGE WAREHOUSES,
SPANS NORMALLY 18 FT TO
28 FT,
SLAB 8 IN. TO 10 IN.
THICK,
SUPPORT BEAMS AND COLUMNS
USUALLY CONCRETE,
DESIGN CRITERION 150 TO
250 PSF.

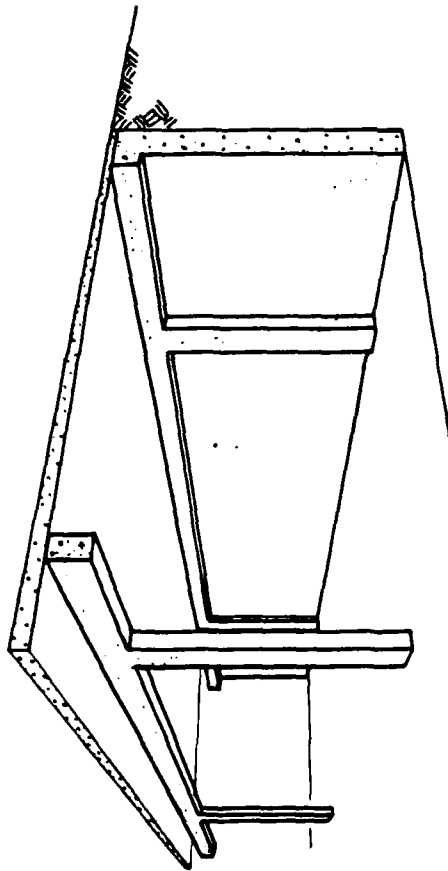
RADIATION		SURVIVAL RATING
Pf	KEY	
40	0.5	VI ⁺
100	1	VI ⁺
1000	2.5	VI

CONCRETE CONSTRUCTION—Floors

HOLLOW-CORE — Heavy Design

AS BUILT

CONCRETE CONSTRUCTION - FLOOR				SURVIVAL RATING VI		
ONE-WAY SLAB - HEAVY DESIGN				SUPERIMPOSED DESIGN LOAD-150 to 250 PSF		
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7
None Required	40	0.5	VI ⁺	<u>DOES NOT REQUIRE UPGRADING</u>		
	100	1	VI ⁺			
	1000	2.5	VI			



TYPICALLY FOUND IN HEAVY
MANUFACTURING BUILDINGS
AND STORAGE WAREHOUSES.
SPANS NORMALLY 16 FT TO
30 FT.
SLAB 8 IN. TO 12 IN.
THICK.
SUPPORT BEAMS AND COLUMNS
USUALLY CONCRETE.
DESIGN CRITERION 150 TO
250 PSF.

RADIATION		SURVIVAL RATING
Pf	KEY	
40	N	VI ⁺
100	0.5	VI ⁺
1000	2.0	VI

CONCRETE CONSTRUCTION--Floors ONE-WAY SLAB - Heavy Design

Addition - 5/81

4-29

AS BUILT

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Page

WOOD CONSTRUCTION - ROOFS

Timber Joist

Glulam

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STEEL-LIGHT CONSTRUCTION - ROOFS

Open-Web Joist W/Timber Deck,
Insulation

5-3

STEEL-HEAVY CONSTRUCTION - ROOFS

Open-Web Joist W/Metal Deck,
Insulation

5-4

CONCRETE CONSTRUCTION - ROOFS

Double Tee

Waffle Slab

Flat Slab

Flat Plate

One-Way Joist

Hollow-Core

One-Way Slab

5-5

5-6

5-7

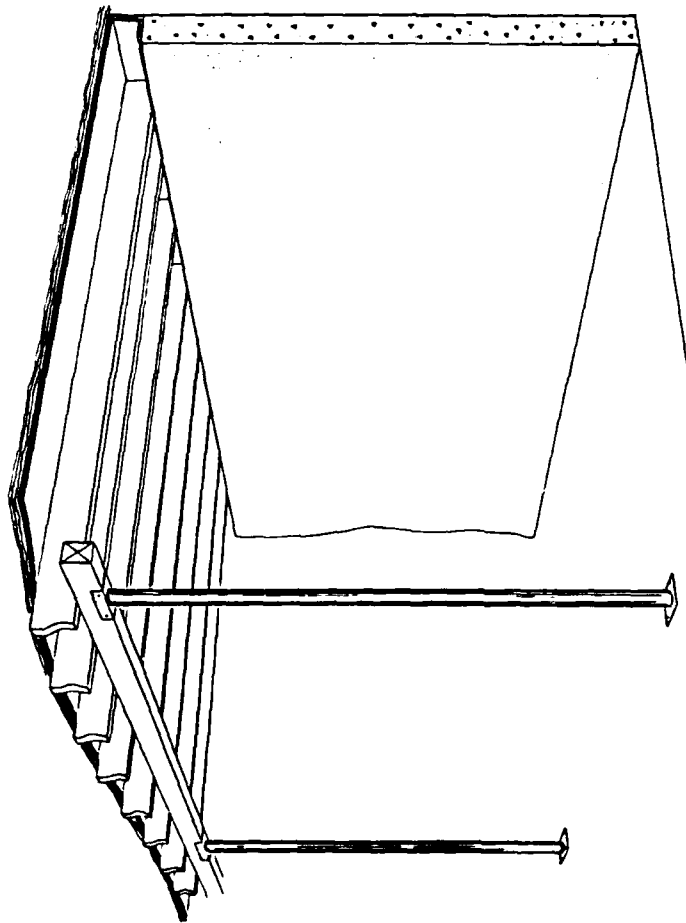
5-8

5-9

5-10

5-11

WOOD CONSTRUCTION - ROOFS					SURVIVAL RATING VI		
TIMBER JOIST							
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7	
Two rows of Wood Stud Walls, one each at 1/3 span	40	1	VI ⁺	Page 6-23	Page 8-1	Page 7-1	
	100	1.5	VI				
	1000	3	0				
Two rows of Post and Beam Shores, one each at 1/3 span	40	1	VI ⁺	Page 6-24	Page 8-2, 8-3	Page 7-2	
	100	1.5	VI				
	1000	3	0				



SPANS NORMALLY 6 FT. TO 24 FT.,
 DEPTH OF JOIST 6 IN. TO 12 IN.
 SUPPORTED BEAM CAN BE EITHER
 STEEL OR WOOD, AND SUPPORT POSTS
 WOOD OR STEEL PIPE.
 DECK TOPPED WITH PLYWOOD, IN-
 SULATION, AND BUILT-UP ROOF.

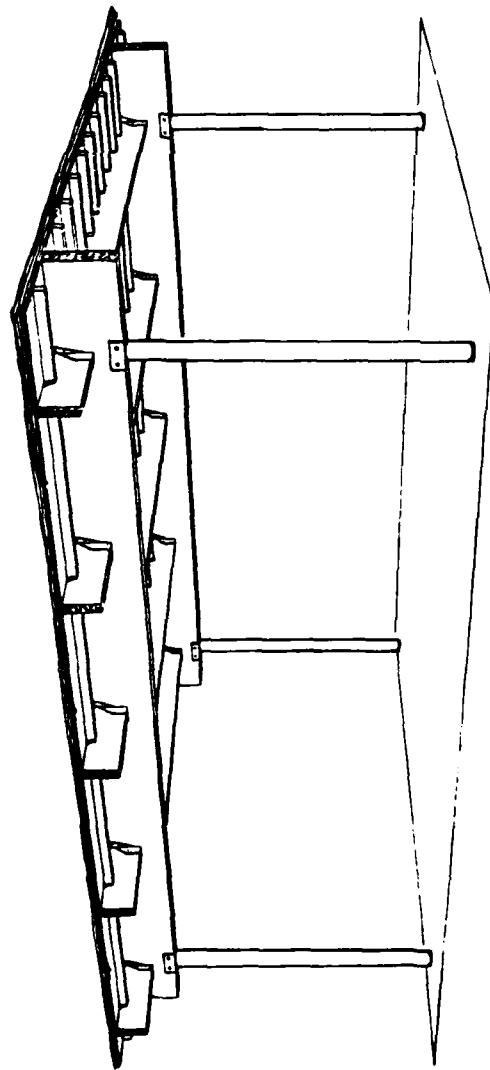
RADIATION		SURVIVAL RATING
Pf	KEY	
40	I	+
100	-	-
1000	-	-

WOOD CONSTRUCTION-Roofs

TIMBER JOIST

AS BUILT

WOOD CONSTRUCTION - ROOFS					SURVIVAL RATING VI		
GLULAM							
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7	
Two rows of Wood Stud Walls, one each at 1/3 span	40	1	VI ⁺	Page 6-25	Page 8-1	Page 7-1	
	100	1.5	VI				
	1000	3	0				
Two rows of Post and Beam Shores, one each at 1/3 span	40	1	VI ⁺	Page 6-26	Page 8-2, 8-3	Page 7-2	
	100	1.5	VI				
	1000	3	0				



SPANS NORMALLY 6 FT. TO 24 FT. DEPTH OF GLULAM JOIST 4 IN. TO 8 IN., SUPPORTED ON GLULAM BEAM, NORMALLY 8 IN. TO 16 IN. DEEP.

SUPPORT POSTS WOOD OR STEEL PIPE.

DECK TOPPED WITH PLYWOOD, INSULATION, AND BUILT-UP ROOF.

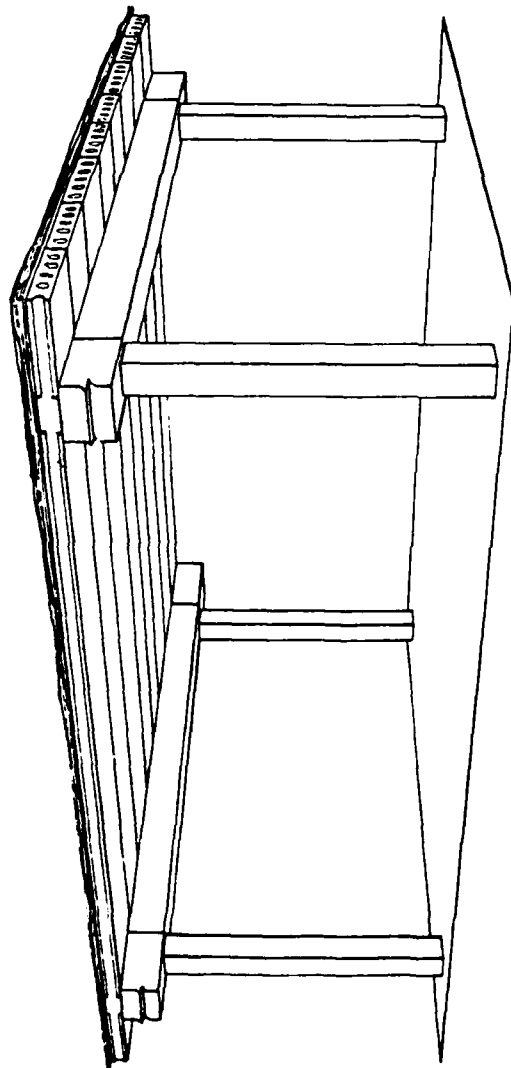
RADIATION		SURVIVAL RATING
P _F	KEY	
40	1	+
100	-	-
1000	-	-

WOOD CONSTRUCTION--Roofs

GLULAM

AS BUILT

STEEL - LIGHT CONSTRUCTION - ROOFS					SURVIVAL RATING VI		
OPEN-WEB JOIST W/TIMBER DECK, INSULATION							
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7	
Two rows of Wood Stud Walls, one each at 1/3 span	40	1	0	Page 6-27	Page 8-1	Page 7-1	
	100	1.5	0				
	1000	3	+				
Two rows of Post and Beam Shores, one each at 1/3 span	40	1	0	Page 6-28	Page 8-2, 8-3	Page 7-2	
	100	1.5	0				
	1000	3	+				



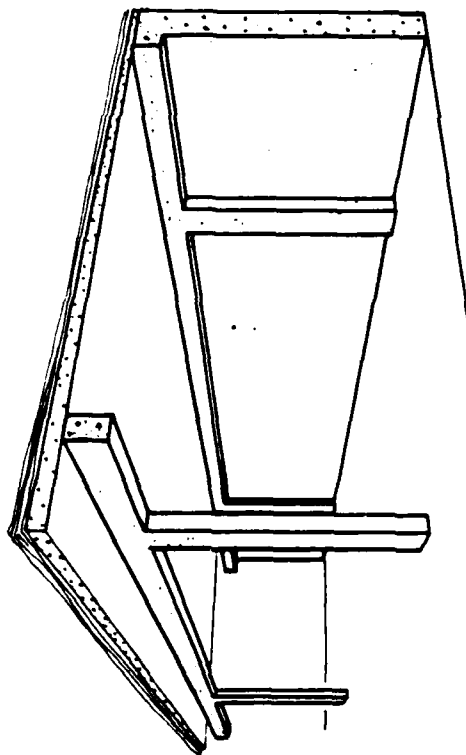
SPANS NORMALLY 15 FT TO 40 FT,
SLAB 4 IN. TO 10 IN. THICK.
SUPPORT BEAMS AND COLUMNS
USUALLY CONCRETE.
DECK TOPPED WITH INSULATION
AND BUILT-UP ROOF.

RADIATION		SURVIVAL RATING
Pf	KEY	
40	1	0
100	1.5	+
1000	-	-

CONCRETE CONSTRUCTION-ROOFS HOLLOW-CORE

AS BUILT

CONCRETE CONSTRUCTION - ROOFS					SURVIVAL RATING VI		
ONE-WAY SLAB							
SHORING SYSTEM REQUIRED	P _f	KEY	S _R	ILLUSTRATION AND DETAILS-Sect. 6	CHARTS FOR SIZE AND SPACING OF SHORES Sect. 8	WORKSHEETS Sect. 7	
Wood Stud Wall at Midspan	40	0.5	VI ⁺	Page 6-40	Page 8-1	Page 7-1	
	100	1	VI				
	1000	2.5	0				
Post and Beam Shores at Mid- span	40	0.5	VI ⁺	Page 6-41	Page 8-2, 8-3	Page 7-2	
	100	1	VI				
	1000	2.5	0				



SPANS NORMALLY 15 FT TO 30 FT.
SLAB 6 IN. TO 10 IN. THICK,
SUPPORT BEAMS AND COLUMNS
USUALLY CONCRETE.
DECK TOPPED WITH INSULATION
AND BUILT-UP ROOF.

RADIATION		SURVIVAL RATING
Pf	KEY	
40	0.5	0
100	1	0
1000	2.5	-

CONCRETE CONSTRUCTION—Roofs ONE-WAY SLAB

Addition - 5/81

5-11

AS BUILT

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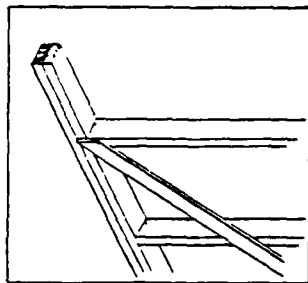
<u>Page</u>		<u>Page</u>
	<u>WOOD CONSTRUCTION - FLOORS</u>	<u>CONCRETE CONSTRUCTION - FLOORS</u>
	Timber Joist - Stud Wall Upgrading	Hollow-Core - Stud Wall Upgrading
	- Post & Beam Upgrading	- Post & Beam Upgrading
	- King Post Truss Upgrading	
	- Flange Upgrading	<u>WOOD CONSTRUCTION - ROOFS</u>
	- Boxed Beam Upgrading	Timber Joist - Stud Wall Upgrading
		- Post & Beam Upgrading
	Glulam - Stud Wall Upgrading	Glulam - Stud Wall Upgrading
	- Post & Beam Upgrading	- Post & Beam Upgrading
	- King Post Truss Upgrading	
	<u>STEEL - LIGHT CONSTRUCTION - FLOORS</u>	<u>STEEL LIGHT CONSTRUCTION - ROOFS</u>
	Open-Web Joist - Stud Wall Upgrading	Open-Web Joist - Stud Wall Upgrading
	- Post & Beam Upgrading	- Post & Beam Upgrading
	- King Post Truss Upgrading	
	<u>STEEL - HEAVY CONSTRUCTION - FLOORS</u>	<u>STEEL HEAVY CONSTRUCTION - ROOFS</u>
	Beam and Slab - Stud Wall Upgrading	Open-Web Joist - Stud Wall Upgrading
	- Post & Beam Upgrading	- Post & Beam Upgrading
	<u>CONCRETE CONSTRUCTION - FLOORS</u>	<u>CONCRETE CONSTRUCTION - ROOFS</u>
	Double Tee - Stud Wall Upgrading	Double Tee - Stud Wall Upgrading
	- Post & Beam Upgrading	- Post & Beam Upgrading
	Waffle Slab - Post Upgrading	Waffle Slab - Post Upgrading
	Flat Slab - Post Upgrading	Flat Slab - Post Upgrading
	Flat Plate - Post Upgrading	Flat Plate - Post Upgrading
	One-Way Joist - Stud Wall Upgrading	One-Way Joist - Stud Wall Upgrading
	- Post & Beam Upgrading	- Post & Beam Upgrading
	One-Way Slab - Stud Wall Upgrading	Hollow-Core - Stud Wall Upgrading
	- Post & Beam Upgrading	- Post & Beam Upgrading
		One-Way Slab - Stud Wall Upgrading
		- Post & Beam Upgrading

STUD WALL

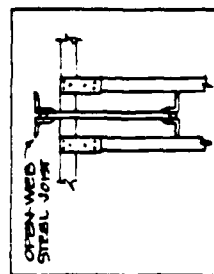
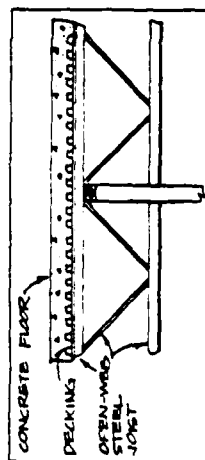
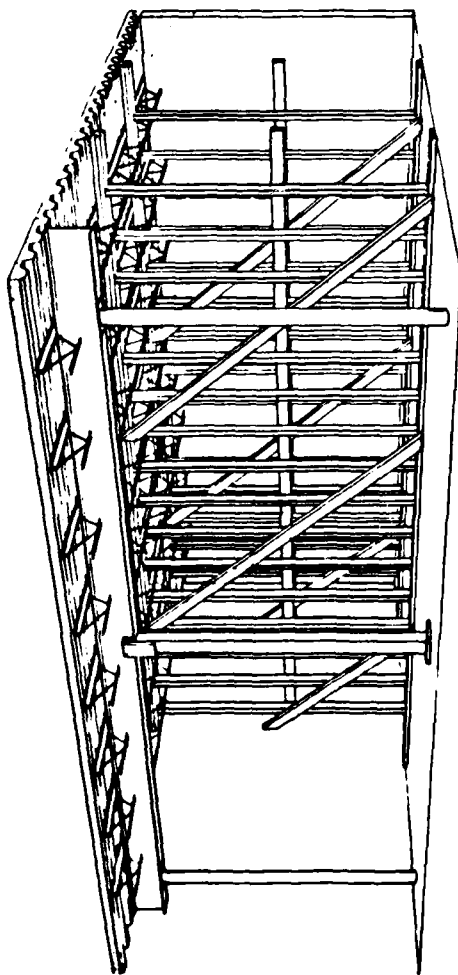
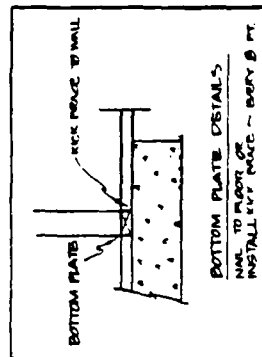
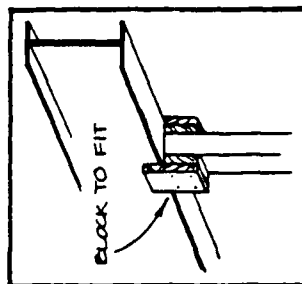
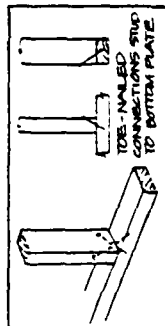
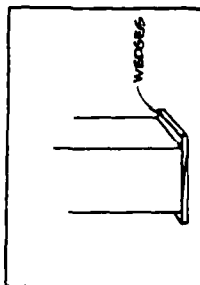
RESOURCE LIST

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Timber (Studs & Plates)	_____	_____
2. Bracing Material (Plywood Sheeting or nom. 1-in. Timber)	_____	_____
3. Nails	_____	_____
4. Hammer	_____	_____
5. Saw	_____	_____
6. Wedges	_____	_____
7. Tape measure/yardstick, etc.	_____	_____
8. _____	_____	_____
9. _____	_____	_____
10. _____	_____	_____

details



WALL TYPE	WALL TYPE	WALL TYPE
CONCRETE (NORMAL)	8" x 8"	10" x 10"
1" x 1"	8" x 8"	10" x 10"
2" x 2"	8" x 8"	10" x 10"
3" x 3"	8" x 8"	10" x 10"
4" x 4"	8" x 8"	10" x 10"
* when 10" x 10" of base plate		
when 10" x 10" of base plate		
when 10" x 10" of base plate		



STEEL-LIGHT CONSTRUCTION-Floors

OPEN-WEB JOIST

Revised - 2/81

6-9

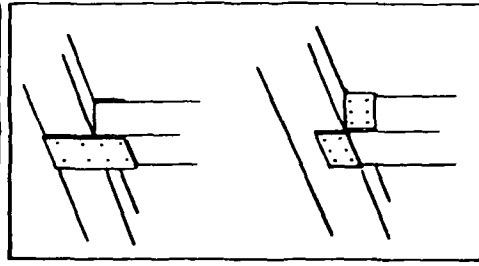
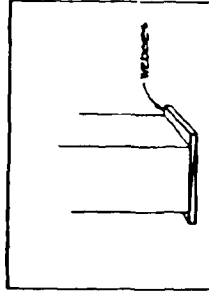
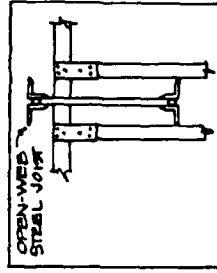
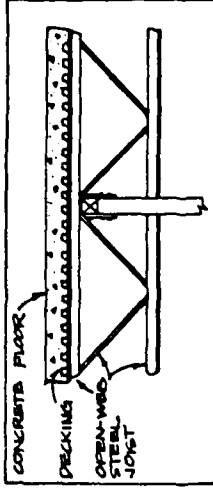
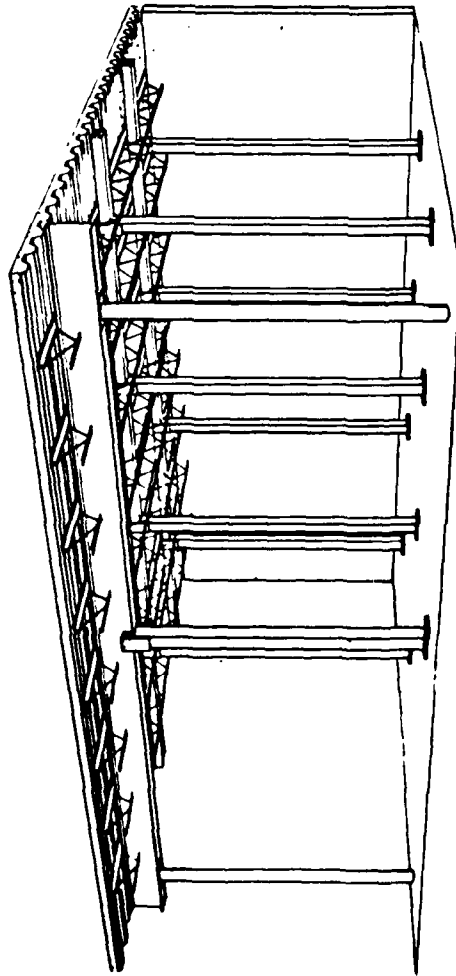
stud wall upgrading

POST & BEAM

RESOURCE LIST

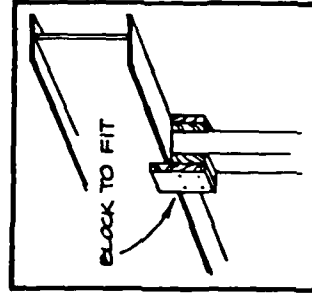
<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Timber (Posts)		
2. Timber (Beams)		
3. Nails		
4. Hammer		
5. Saw		
6. Wedges		
7. Tape measure/yardstick, etc.		
8.		
9.		
10.		

details



NAILING SCHEDULE	NAIL SIZE
BOARD SIZE (MINIMUM)	NAIL SIZE
1 x 6	6d, 6d
2 x 6	8d, 10d, 12d
3 x 6	10d, 12d, 14d, 16d
4 x 6	12d, 14d, 16d, 18d

a where 10 = width of flange
 when 10 = 2 in. use 6 nails
 when 11 = 3 in. use 6 nails
 when 12 = 4 in. use 4 nails



STEEL-LIGHT CONSTRUCTION-Floors OPEN-WEB JOIST

Revised - 5/81

6-10

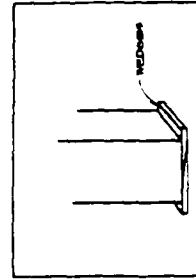
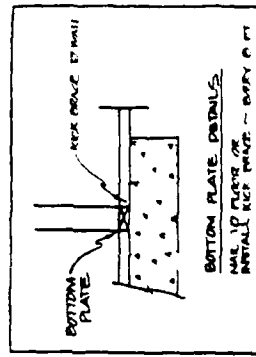
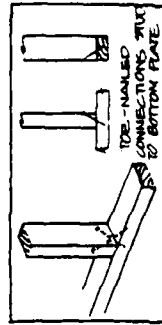
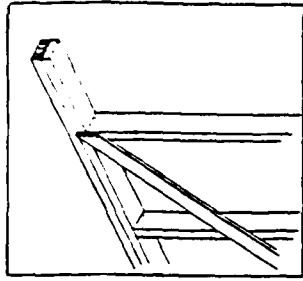
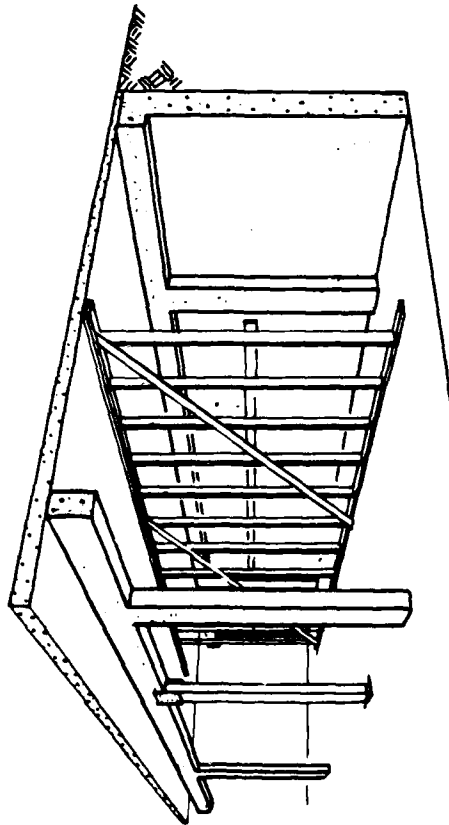
post & beam
upgrading

KING POST TRUSS

RESOURCE LIST

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Timber		
2. Cable or Rods		
3. Connections		
4. Nails		
5. Hammer		
6. Saw		
7. Wedges		
8. Tape measure/yardstick, etc.		
9. _____		
10. _____		

details



NAILED CONNECTION	NAILED CONNECTION	NAILED CONNECTION
1 x 4	2 x 4	4 x 4
2 x 4	2 x 6	2 x 8
2 x 6	2 x 8	2 x 10
2 x 8	2 x 10	2 x 12
2 x 10	2 x 12	2 x 14
2 x 12	2 x 14	2 x 16
2 x 14	2 x 16	2 x 18
2 x 16	2 x 18	2 x 20
2 x 18	2 x 20	2 x 22
2 x 20	2 x 22	2 x 24
2 x 22	2 x 24	2 x 26
2 x 24	2 x 26	2 x 28
2 x 26	2 x 28	2 x 30
2 x 28	2 x 30	2 x 32
2 x 30	2 x 32	2 x 34
2 x 32	2 x 34	2 x 36
2 x 34	2 x 36	2 x 38
2 x 36	2 x 38	2 x 40
2 x 38	2 x 40	2 x 42
2 x 40	2 x 42	2 x 44
2 x 42	2 x 44	2 x 46
2 x 44	2 x 46	2 x 48
2 x 46	2 x 48	2 x 50
2 x 48	2 x 50	2 x 52
2 x 50	2 x 52	2 x 54
2 x 52	2 x 54	2 x 56
2 x 54	2 x 56	2 x 58
2 x 56	2 x 58	2 x 60
2 x 58	2 x 60	2 x 62
2 x 60	2 x 62	2 x 64
2 x 62	2 x 64	2 x 66
2 x 64	2 x 66	2 x 68
2 x 66	2 x 68	2 x 70
2 x 68	2 x 70	2 x 72
2 x 70	2 x 72	2 x 74
2 x 72	2 x 74	2 x 76
2 x 74	2 x 76	2 x 78
2 x 76	2 x 78	2 x 80
2 x 78	2 x 80	2 x 82
2 x 80	2 x 82	2 x 84
2 x 82	2 x 84	2 x 86
2 x 84	2 x 86	2 x 88
2 x 86	2 x 88	2 x 90
2 x 88	2 x 90	2 x 92
2 x 90	2 x 92	2 x 94
2 x 92	2 x 94	2 x 96
2 x 94	2 x 96	2 x 98
2 x 96	2 x 98	2 x 100

2 where $b =$ width of beam
 when $b = 2$ in. use 2 nails
 when $b = 4$ in. use 4 nails
 when $b = 6$ in. use 6 nails

CONCRETE CONSTRUCTION—Floors ONE-WAY SLAB

Addition - 5/81

6-20A

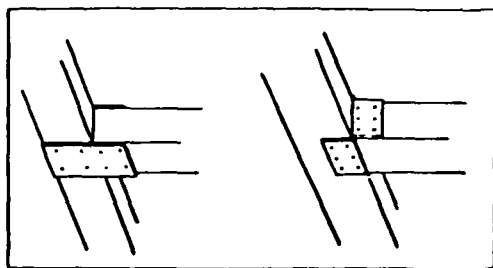
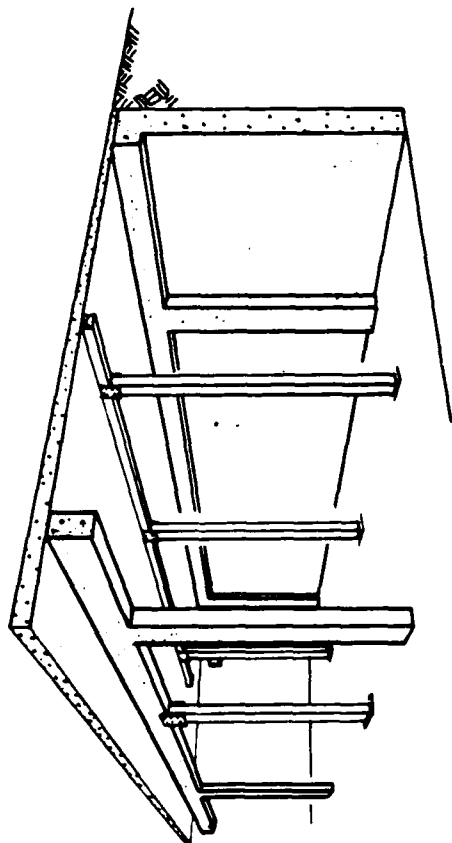
stud wall upgrading

POST & BEAM

RESOURCE LIST

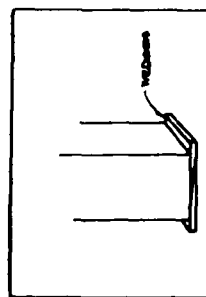
<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Timber (Posts)		
2. Timber (Beams)		
3. Nails		
4. Hammer		
5. Saw		
6. Wedges		
7. Tape measure/yardstick, etc.		
8.		
9.		
10.		

details



BEAM SIZE (NOMINAL)	NAIL SIZE
1" x 6"	6d, 10d
2" x 6"	8d, 10d, 12d
3" x 6"	10d, 12d, 30d
4" x 6"	10d, 12d, 30d
6" x 6"	10d, 12d, 30d

a where b = width of beams
 when b = 2" max 2 nails
 when b = 4" max 3 nails
 when b = 6" max 4 nails



CONCRETE CONSTRUCTION—Floors ONE-WAY SLAB

6-20B

Addition - 5/81

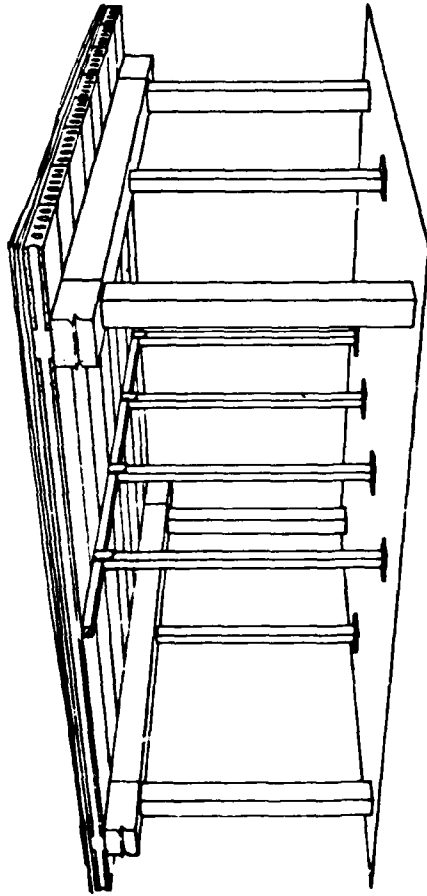
post & beam
upgrading

STUD WALL

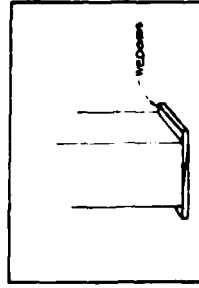
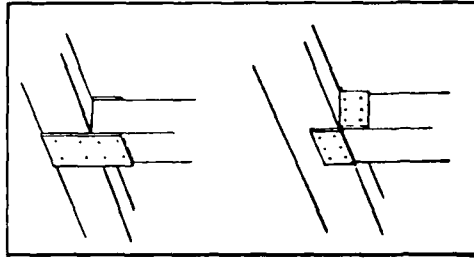
RESOURCE LIST

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Timber (Studs & Plates)		
2. Bracing Material (Plywood Sheeting or nom. 1-in. Timber)		
3. Nails		
4. Hammer		
5. Saw		
6. Wedges		
7. Tape measure/yardstick, etc.		
8. _____		
9. _____		
10. _____		

Addition - 5/81



details



Beam No.	Post No.	Beam No.	Post No.
1	1	2	2
3	3	4	4
5	5	6	6
7	7	8	8
9	9	10	10
11	11	12	12
13	13	14	14
15	15	16	16
17	17	18	18
19	19	20	20
21	21	22	22
23	23	24	24
25	25	26	26
27	27	28	28
29	29	30	30
31	31	32	32
33	33	34	34
35	35	36	36
37	37	38	38
39	39	40	40
41	41	42	42
43	43	44	44
45	45	46	46
47	47	48	48
49	49	50	50
51	51	52	52
53	53	54	54
55	55	56	56
57	57	58	58
59	59	60	60
61	61	62	62
63	63	64	64
65	65	66	66
67	67	68	68
69	69	70	70
71	71	72	72
73	73	74	74
75	75	76	76
77	77	78	78
79	79	80	80
81	81	82	82
83	83	84	84
85	85	86	86
87	87	88	88
89	89	90	90
91	91	92	92
93	93	94	94
95	95	96	96
97	97	98	98
99	99	100	100

CONCRETE CONSTRUCTION—Roofs HOLLOW—CORE

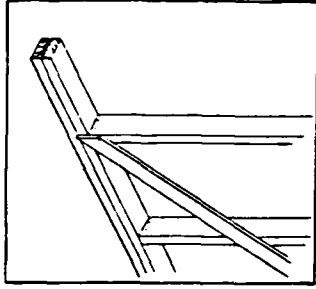
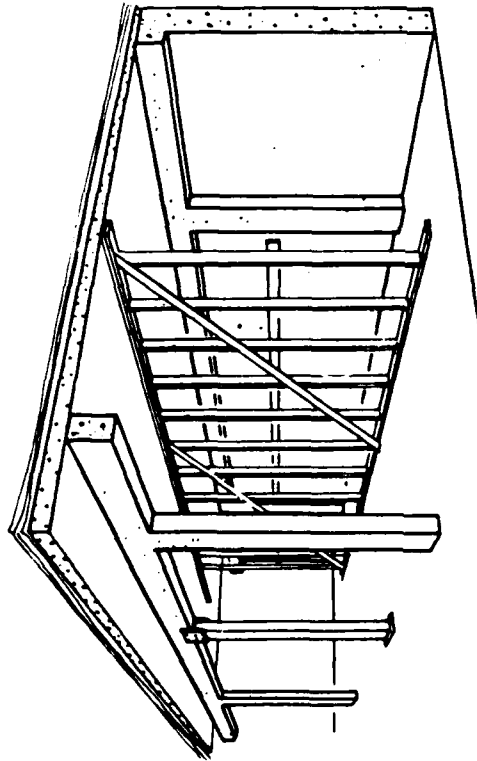
post & beam
upgrading

STUD WALL

RESOURCE LIST

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Timber (Studs & Plates)	_____	_____
2. Bracing Material (Plywood Sheeting or nom. 1-in. Timber)	_____	_____
3. Nails	_____	_____
4. Hammer	_____	_____
5. Saw	_____	_____
6. Wedges	_____	_____
7. Tape measure/yardstick, etc.	_____	_____
8. _____	_____	_____
9. _____	_____	_____
10. _____	_____	_____

details



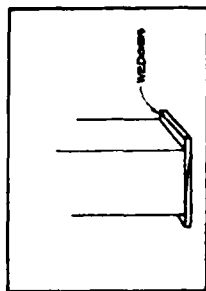
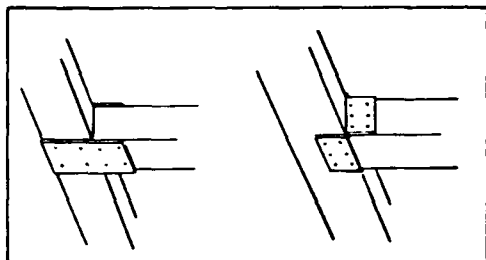
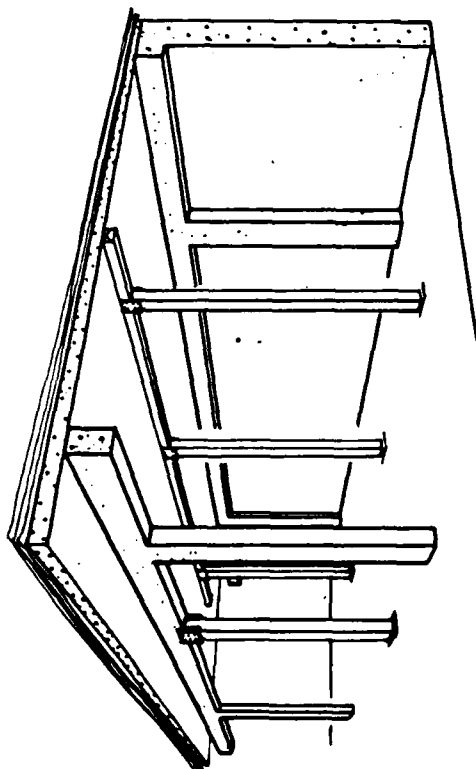
NAILING SCHEDULE	1/4" MIN. 2x4
1 x 4	6d, 12"
2 x 4	8d, 10", 12"
3 x 4	10d, 12", 16"
4 x 4	12d, 16", 20"
4 x 6	16d, 20", 24"
4 x 8	20d, 24", 30"
4 x 10	24d, 30", 36"
4 x 12	30d, 36", 42"
4 x 14	36d, 42", 48"
4 x 16	42d, 48", 54"
4 x 18	48d, 54", 60"
4 x 20	54d, 60", 66"
4 x 22	60d, 66", 72"
4 x 24	66d, 72", 78"
4 x 26	72d, 78", 84"
4 x 28	78d, 84", 90"
4 x 30	84d, 90", 96"
4 x 32	90d, 96", 102"
4 x 34	96d, 102", 108"
4 x 36	102d, 108", 114"
4 x 38	108d, 114", 120"
4 x 40	114d, 120", 126"
4 x 42	120d, 126", 132"
4 x 44	126d, 132", 138"
4 x 46	132d, 138", 144"
4 x 48	138d, 144", 150"
4 x 50	144d, 150", 156"
4 x 52	150d, 156", 162"
4 x 54	156d, 162", 168"
4 x 56	162d, 168", 174"
4 x 58	168d, 174", 180"
4 x 60	174d, 180", 186"
4 x 62	180d, 186", 192"
4 x 64	186d, 192", 198"
4 x 66	192d, 198", 204"
4 x 68	198d, 204", 210"
4 x 70	204d, 210", 216"
4 x 72	210d, 216", 222"
4 x 74	216d, 222", 228"
4 x 76	222d, 228", 234"
4 x 78	228d, 234", 240"
4 x 80	234d, 240", 246"
4 x 82	240d, 246", 252"
4 x 84	246d, 252", 258"
4 x 86	252d, 258", 264"
4 x 88	258d, 264", 270"
4 x 90	264d, 270", 276"
4 x 92	270d, 276", 282"
4 x 94	276d, 282", 288"
4 x 96	282d, 288", 294"
4 x 98	288d, 294", 300"
4 x 100	294d, 300", 306"
4 x 102	300d, 306", 312"
4 x 104	306d, 312", 318"
4 x 106	312d, 318", 324"
4 x 108	318d, 324", 330"
4 x 110	324d, 330", 336"
4 x 112	330d, 336", 342"
4 x 114	336d, 342", 348"
4 x 116	342d, 348", 354"
4 x 118	348d, 354", 360"
4 x 120	354d, 360", 366"
4 x 122	360d, 366", 372"
4 x 124	366d, 372", 378"
4 x 126	372d, 378", 384"
4 x 128	378d, 384", 390"
4 x 130	384d, 390", 396"
4 x 132	390d, 396", 402"
4 x 134	396d, 402", 408"
4 x 136	402d, 408", 414"
4 x 138	408d, 414", 420"
4 x 140	414d, 420", 426"
4 x 142	420d, 426", 432"
4 x 144	426d, 432", 438"
4 x 146	432d, 438", 444"
4 x 148	438d, 444", 450"
4 x 150	444d, 450", 456"
4 x 152	450d, 456", 462"
4 x 154	456d, 462", 468"
4 x 156	462d, 468", 474"
4 x 158	468d, 474", 480"
4 x 160	474d, 480", 486"
4 x 162	480d, 486", 492"
4 x 164	486d, 492", 498"
4 x 166	492d, 498", 504"
4 x 168	498d, 504", 510"
4 x 170	504d, 510", 516"
4 x 172	510d, 516", 522"
4 x 174	516d, 522", 528"
4 x 176	522d, 528", 534"
4 x 178	528d, 534", 540"
4 x 180	534d, 540", 546"
4 x 182	540d, 546", 552"
4 x 184	546d, 552", 558"
4 x 186	552d, 558", 564"
4 x 188	558d, 564", 570"
4 x 190	564d, 570", 576"
4 x 192	570d, 576", 582"
4 x 194	576d, 582", 588"
4 x 196	582d, 588", 594"
4 x 198	588d, 594", 600"
4 x 200	594d, 600", 606"
4 x 202	600d, 606", 612"
4 x 204	606d, 612", 618"
4 x 206	612d, 618", 624"
4 x 208	618d, 624", 630"
4 x 210	624d, 630", 636"
4 x 212	630d, 636", 642"
4 x 214	636d, 642", 648"
4 x 216	642d, 648", 654"
4 x 218	648d, 654", 660"
4 x 220	654d, 660", 666"
4 x 222	660d, 666", 672"
4 x 224	666d, 672", 678"
4 x 226	672d, 678", 684"
4 x 228	678d, 684", 690"
4 x 230	684d, 690", 696"
4 x 232	690d, 696", 702"
4 x 234	696d, 702", 708"
4 x 236	702d, 708", 714"
4 x 238	708d, 714", 720"
4 x 240	714d, 720", 726"
4 x 242	720d, 726", 732"
4 x 244	726d, 732", 738"
4 x 246	732d, 738", 744"
4 x 248	738d, 744", 750"
4 x 250	744d, 750", 756"
4 x 252	750d, 756", 762"
4 x 254	756d, 762", 768"
4 x 256	762d, 768", 774"
4 x 258	768d, 774", 780"
4 x 260	774d, 780", 786"
4 x 262	780d, 786", 792"
4 x 264	786d, 792", 800"
4 x 266	792d, 800", 808"
4 x 268	800d, 808", 816"
4 x 270	808d, 816", 824"
4 x 272	816d, 824", 832"
4 x 274	824d, 832", 840"
4 x 276	832d, 840", 848"
4 x 278	840d, 848", 856"
4 x 280	848d, 856", 864"
4 x 282	856d, 864", 872"
4 x 284	864d, 872", 880"
4 x 286	872d, 880", 888"
4 x 288	880d, 888", 896"
4 x 290	888d, 896", 904"
4 x 292	896d, 904", 912"
4 x 294	904d, 912", 920"
4 x 296	912d, 920", 928"
4 x 298	920d, 928", 936"
4 x 300	928d, 936", 944"
4 x 302	936d, 944", 952"
4 x 304	944d, 952", 960"
4 x 306	952d, 960", 968"
4 x 308	960d, 968", 976"
4 x 310	968d, 976", 984"
4 x 312	976d, 984", 992"
4 x 314	984d, 992", 1000"
4 x 316	992d, 1000", 1008"
4 x 318	1000d, 1008", 1016"
4 x 320	1008d, 1016", 1024"
4 x 322	1016d, 1024", 1032"
4 x 324	1024d, 1032", 1040"
4 x 326	1032d, 1040", 1048"
4 x 328	1040d, 1048", 1056"
4 x 330	1048d, 1056", 1064"
4 x 332	1056d, 1064", 1072"
4 x 334	1064d, 1072", 1080"
4 x 336	1072d, 1080", 1088"
4 x 338	1080d, 1088", 1096"
4 x 340	1088d, 1096", 1104"
4 x 342	1096d, 1104", 1112"
4 x 344	1104d, 1112", 1120"
4 x 346	1112d, 1120", 1128"
4 x 348	1120d, 1128", 1136"
4 x 350	1128d, 1136", 1144"
4 x 352	1136d, 1144", 1152"
4 x 354	1144d, 1152", 1160"
4 x 356	1152d, 1160", 1168"
4 x 358	1160d, 1168", 1176"
4 x 360	1168d, 1176", 1184"
4 x 362	1176d, 1184", 1192"
4 x 364	1184d, 1192", 1200"
4 x 366	1192d, 1200", 1208"
4 x 368	1200d, 1208", 1216"
4 x 370	1208d, 1216", 1224"
4 x 372	1216d, 1224", 1232"
4 x 374	1224d, 1232", 1240"
4 x 376	1232d, 1240", 1248"
4 x 378	1240d, 1248", 1256"
4 x 380	1248d, 1256", 1264"
4 x 382	1256d, 1264", 1272"
4 x 384	1264d, 1272", 1280"
4 x 386	1272d, 1280", 1288"
4 x 388	1280d, 1288", 1296"
4 x 390	1288d, 1296", 1304"
4 x 392	1296d, 1304", 1312"
4 x 394	1304d, 1312", 1320"
4 x 396	1312d, 1320", 1328"
4 x 398	1320d, 1328", 1336"
4 x 400	1328d, 1336", 1344"
4 x 402	1336d, 1344", 1352"
4 x 404	1344d, 1352", 1360"
4 x 406	1352d, 1360", 1368"
4 x 408	1360d, 1368", 1376"
4 x 410	1368d, 1376", 1384"
4 x 412	1376d, 1384", 1392"
4 x 414	1384d, 1392", 1400"
4 x 416	1392d, 1400", 1408"
4 x 418	1400d, 1408", 1416"
4 x 420	1408d, 1416", 1424"
4 x 422	1416d, 1424", 1432"
4 x 424	1424d, 1432", 1440"
4 x 426	1432d, 1440", 1448"
4 x 428	1440d, 1448", 1456"
4 x 430	1448d, 1456", 1464"
4 x 432	1456d, 1464", 1472"
4 x 434	1464d, 1472", 1480"
4 x 436	1472d, 1480", 1488"
4 x 438	1480d, 1488", 1496"
4 x 440	1488d, 1496", 1504"
4 x 442	1496d, 1504", 1512"
4 x 444	1504d, 1512", 1520"
4 x 446	1512d, 1520", 1528"
4 x 448	1520d, 1528", 1536"
4 x 450	1528d, 1536", 1544"
4 x 452	1536d, 1544", 1552"
4 x 454	1544d, 1552", 1560"
4 x 456	1552d, 1560", 1568"
4 x 458	1560d, 1568", 1576"
4 x 460	1568d, 1576", 1584"
4 x 462	1576d, 1584", 1592"
4 x 464	1584d, 1592", 1600"
4 x 466	1592d, 1600", 1608"
4 x 468	1600d, 1608", 1616"
4 x 470	1608d, 1616", 1624"
4 x 472	1616d, 1624", 1632"
4 x 474	1624d, 1632", 1640"
4 x 476	1632d, 1640", 1648"
4 x 478	1640d, 1648", 1656"
4 x 480	1648d, 1656", 1664"
4 x 482	1656d, 1664", 1672"
4 x 484	1664d, 1672", 1680"
4 x 486	1672d, 1680", 1688"
4 x 488	1680d, 1688", 1696"
4 x 490	1688d, 1696", 1704"
4 x 492	1696d, 1704", 1712"
4 x 494	1704d, 1712", 1720"
4 x 496	1712d, 1720", 1728"
4 x 498	1720d, 1728", 1736"
4 x 500	1728d, 1736", 1744"
4 x 502	1736d, 1744", 1752"
4 x 504	1744d, 1752", 1760"
4 x 506	1752d, 1760", 1768"
4 x 508	1760d, 1768", 1776"
4 x 510	1768d, 1776", 1784"
4 x 512	1776d, 1784", 1792"
4 x 514	1784d, 1792", 1800"
4 x 516	1792d, 1800", 1808"
4 x 518	1800d, 1808", 1816"
4 x 520	1808d, 1816", 1824"
4 x 522	1816d, 1824", 1832"
4 x 524	1824d, 1832", 1840"
4 x 526	1832d, 1840", 1848"
4 x 528	1840d, 1848", 1856"
4 x 530	1848d, 1856", 1864"
4 x 532	1856d, 1864", 1872"
4 x 534	1864d, 1872", 1880"
4 x 536	1872d, 1880", 1888"
4 x 538	1880d, 1888", 1896"
4 x 540	1888d, 1896", 1904"
4 x 542	1896d, 1904", 1912"
4 x 544	1904d, 1912", 1920"
4 x 546	1912d, 1920", 1928"
4 x 548	1920d, 1928", 1936"
4 x 550	1928d, 1936", 1944"
4 x 552	1936d, 1944", 1952"
4 x 554	1944d, 1952", 1960"
4 x 556	1952d, 1960", 1968"
4 x 558	1960d, 1968", 1976"
4 x 560	1968d, 1976", 1984"
4 x 562	1976d, 1984", 1992"
4 x 564	1984d, 1992", 2000"
4 x 566	1992d, 2000", 2008"
4 x 568	2000d, 2008", 2016"
4 x 570	2008d, 2016", 2024"
4 x 572	2016d, 2024", 2032"
4 x 574	2024d, 2032", 2040"
4 x 576	2032d, 2040", 2048"
4 x 578	2040d, 2048", 2056"
4 x 580	2048d, 2056", 2064"
4 x 582	2056d, 2064", 2072"
4 x 584	2064d, 2072", 2080"
4 x 586	2072d, 2080", 2088"
4 x 588	2080d, 2088", 2096"
4 x 590	2088d, 2096", 2104"
4 x 592	2096d, 2104", 2112"
4 x 594	2104d, 2112", 2120"
4 x 596	2112d, 2120", 2128"
4 x 598	2120d, 2128", 2136"
4 x 600	2128d, 2136", 2144"
4 x 602	2136d, 2144", 2152"
4 x 604	2144d, 2152", 2160"
4 x 606	2152d, 2160", 2168"
4 x 608	2160d, 2168", 2176"
4 x 610	2168d, 2176", 2184"
4 x 612	2176d, 2184", 2192"
4 x 614	2184d, 2192", 2200"
4 x 616	2192d, 2200", 2208"
4 x 618	2200d, 2208", 2216"
4 x 620	2208d, 2216", 2224"
4 x 622	2216d, 2224", 2232"
4 x 624	2224d, 2232", 2240"
4 x 626	2232d, 2240", 2248"
4 x 628	2240d, 2248", 2256"
4 x 630	2248d, 2256", 2264"
4 x 632	2256d, 2264", 2272"
4 x 634	2264d, 2272", 2280"
4 x 636	2272d, 2280", 2288"
4 x 638	2280d, 2288", 2296"
4 x 640	2288d, 2296", 2304"
4 x 642	2296d, 2304", 2312"
4 x 644	2304d, 2312", 2320"
4 x 646	2312d, 2320",

POST & BEAM

RESOURCE LIST

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Timber (Posts)		
2. Timber (Beams)		
3. Nails		
4. Hammer		
5. Saw		
6. Wedges		
7. Tape measure/yardstick, etc.		
8.		
9.		
10.		

details



BEAM SIZE (INCHES)	NAILING OR LUGS	MIN. SIZE
1" x 10"	6d, 10d	
2" x 10"	8d, 10d, 12d	
3" x 10"	10d, 12d, 14d	
4" x 10"	12d, 14d, 16d	
5" x 10"	14d, 16d, 18d	
6" x 10"	16d, 18d, 20d	
8" x 10"	18d, 20d, 22d	
10" x 10"	20d, 22d, 24d	
12" x 10"	22d, 24d, 26d	
14" x 10"	24d, 26d, 28d	
16" x 10"	26d, 28d, 30d	
18" x 10"	28d, 30d, 32d	
20" x 10"	30d, 32d, 34d	
22" x 10"	32d, 34d, 36d	
24" x 10"	34d, 36d, 38d	
26" x 10"	36d, 38d, 40d	
28" x 10"	38d, 40d, 42d	
30" x 10"	40d, 42d, 44d	
32" x 10"	42d, 44d, 46d	
34" x 10"	44d, 46d, 48d	
36" x 10"	46d, 48d, 50d	
38" x 10"	48d, 50d, 52d	
40" x 10"	50d, 52d, 54d	
42" x 10"	52d, 54d, 56d	
44" x 10"	54d, 56d, 58d	
46" x 10"	56d, 58d, 60d	
48" x 10"	58d, 60d, 62d	
50" x 10"	60d, 62d, 64d	
52" x 10"	62d, 64d, 66d	
54" x 10"	64d, 66d, 68d	
56" x 10"	66d, 68d, 70d	
58" x 10"	68d, 70d, 72d	
60" x 10"	70d, 72d, 74d	
62" x 10"	72d, 74d, 76d	
64" x 10"	74d, 76d, 78d	
66" x 10"	76d, 78d, 80d	
68" x 10"	78d, 80d, 82d	
70" x 10"	80d, 82d, 84d	
72" x 10"	82d, 84d, 86d	
74" x 10"	84d, 86d, 88d	
76" x 10"	86d, 88d, 90d	
78" x 10"	88d, 90d, 92d	
80" x 10"	90d, 92d, 94d	
82" x 10"	92d, 94d, 96d	
84" x 10"	94d, 96d, 98d	
86" x 10"	96d, 98d, 100d	
88" x 10"	98d, 100d, 102d	
90" x 10"	100d, 102d, 104d	
92" x 10"	102d, 104d, 106d	
94" x 10"	104d, 106d, 108d	
96" x 10"	106d, 108d, 110d	
98" x 10"	108d, 110d, 112d	
100" x 10"	110d, 112d, 114d	
102" x 10"	112d, 114d, 116d	
104" x 10"	114d, 116d, 118d	
106" x 10"	116d, 118d, 120d	
108" x 10"	118d, 120d, 122d	
110" x 10"	120d, 122d, 124d	
112" x 10"	122d, 124d, 126d	
114" x 10"	124d, 126d, 128d	
116" x 10"	126d, 128d, 130d	
118" x 10"	128d, 130d, 132d	
120" x 10"	130d, 132d, 134d	
122" x 10"	132d, 134d, 136d	
124" x 10"	134d, 136d, 138d	
126" x 10"	136d, 138d, 140d	
128" x 10"	138d, 140d, 142d	
130" x 10"	140d, 142d, 144d	
132" x 10"	142d, 144d, 146d	
134" x 10"	144d, 146d, 148d	
136" x 10"	146d, 148d, 150d	
138" x 10"	148d, 150d, 152d	
140" x 10"	150d, 152d, 154d	
142" x 10"	152d, 154d, 156d	
144" x 10"	154d, 156d, 158d	
146" x 10"	156d, 158d, 160d	
148" x 10"	158d, 160d, 162d	
150" x 10"	160d, 162d, 164d	
152" x 10"	162d, 164d, 166d	
154" x 10"	164d, 166d, 168d	
156" x 10"	166d, 168d, 170d	
158" x 10"	168d, 170d, 172d	
160" x 10"	170d, 172d, 174d	
162" x 10"	172d, 174d, 176d	
164" x 10"	174d, 176d, 178d	
166" x 10"	176d, 178d, 180d	
168" x 10"	178d, 180d, 182d	
170" x 10"	180d, 182d, 184d	
172" x 10"	182d, 184d, 186d	
174" x 10"	184d, 186d, 188d	
176" x 10"	186d, 188d, 190d	
178" x 10"	188d, 190d, 192d	
180" x 10"	190d, 192d, 194d	
182" x 10"	192d, 194d, 196d	
184" x 10"	194d, 196d, 198d	
186" x 10"	196d, 198d, 200d	
188" x 10"	198d, 200d, 202d	
190" x 10"	200d, 202d, 204d	
192" x 10"	202d, 204d, 206d	
194" x 10"	204d, 206d, 208d	
196" x 10"	206d, 208d, 210d	
198" x 10"	208d, 210d, 212d	
200" x 10"	210d, 212d, 214d	
202" x 10"	212d, 214d, 216d	
204" x 10"	214d, 216d, 218d	
206" x 10"	216d, 218d, 220d	
208" x 10"	218d, 220d, 222d	
210" x 10"	220d, 222d, 224d	
212" x 10"	222d, 224d, 226d	
214" x 10"	224d, 226d, 228d	
216" x 10"	226d, 228d, 230d	
218" x 10"	228d, 230d, 232d	
220" x 10"	230d, 232d, 234d	
222" x 10"	232d, 234d, 236d	
224" x 10"	234d, 236d, 238d	
226" x 10"	236d, 238d, 240d	
228" x 10"	238d, 240d, 242d	
230" x 10"	240d, 242d, 244d	
232" x 10"	242d, 244d, 246d	
234" x 10"	244d, 246d, 248d	
236" x 10"	246d, 248d, 250d	
238" x 10"	248d, 250d, 252d	
240" x 10"	250d, 252d, 254d	
242" x 10"	252d, 254d, 256d	
244" x 10"	254d, 256d, 258d	
246" x 10"	256d, 258d, 260d	
248" x 10"	258d, 260d, 262d	
250" x 10"	260d, 262d, 264d	
252" x 10"	262d, 264d, 266d	
254" x 10"	264d, 266d, 268d	
256" x 10"	266d, 268d, 270d	
258" x 10"	268d, 270d, 272d	
260" x 10"	270d, 272d, 274d	
262" x 10"	272d, 274d, 276d	
264" x 10"	274d, 276d, 278d	
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270" x 10"	280d, 282d, 284d	
272" x 10"	282d, 284d, 286d	
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280" x 10"	290d, 292d, 294d	
282" x 10"	292d, 294d, 296d	
284" x 10"	294d, 296d, 298d	
286" x 10"	296d, 298d, 300d	
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292" x 10"	302d, 304d, 306d	
294" x 10"	304d, 306d, 308d	
296" x 10"	306d, 308d, 310d	
298" x 10"	308d, 310d, 312d	
300" x 10"	310d, 312d, 314d	
302" x 10"	312d, 314d, 316d	
304" x 10"	314d, 316d, 318d	
306" x 10"	316d, 318d, 320d	
308" x 10"	318d, 320d, 322d	
310" x 10"	320d, 322d, 324d	
312" x 10"	322d, 324d, 326d	
314" x 10"	324d, 326d, 328d	
316" x 10"	326d, 328d, 330d	
318" x 10"	328d, 330d, 332d	
320" x 10"	330d, 332d, 334d	
322" x 10"	332d, 334d, 336d	
324" x 10"	334d, 336d, 338d	
326" x 10"	336d, 338d, 340d	
328" x 10"	338d, 340d, 342d	
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332" x 10"	342d, 344d, 346d	
334" x 10"	344d, 346d, 348d	
336" x 10"	346d, 348d, 350d	
338" x 10"	348d, 350d, 352d	
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346" x 10"	356d, 358d, 360d	
348" x 10"	358d, 360d, 362d	
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380" x 10"	390d, 392d, 394d	
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386" x 10"	396d, 398d, 400d	
388" x 10"	398d, 400d, 402d	
390" x 10"	400d, 402d, 404d	
392" x 10"	402d, 404d, 406d	
394" x 10"	404d, 406d, 408d	
396" x 10"	406d, 408d, 410d	
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462" x 10"	472d, 474d, 476d	
464" x 10"	474d, 476d, 478d	
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480" x 10"	490d, 492d, 494d	
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580" x 10"	590d, 592d, 594d	
582" x 10"	592d, 594d, 596d	
584" x 10"	594d, 596d, 598d	
586" x 10"	596d, 598d, 600d	
588" x 10"	598d, 600d, 602d	
590" x 10"	600d, 602d, 604d	
592" x 10"	602d, 604d, 606d	

Appendix B CLOSURES

Existing Shelters

It is probable that the majority of shelter spaces will need some form of closure. For example, a basement that has had the floor upgraded will probably have a stairway, windows, doors, ventilation ducts, access openings, etc. This section of the appendix describes several methods of closing off such typical openings in the walls or ceilings.

Openings can be bridged by use of a number of readily available materials, such as wood, steel, or concrete. Examples of wood that may be used are fence posts, cut-up power poles, railroad ties, solid doors, and standard beams and plank pieces. Examples of concrete are sidewalk slab sections and curb or gutter pieces; and of steel, plate would appear to be the most practical from a handling and placing standpoint, but steel rolled sections could also be used. Additional materials that may be used to close openings are bags or oil or paper drums filled with sand or earth, broken concrete, bricks, or concrete blocks. Table B-1 contains a list of some of the materials that might be considered for use in closing openings.

With the wood and concrete categories there are material differences, which affect their strength. Wood fence posts, power poles, or railroad ties could be badly splintered or rotted in the center. Wood beams and planks could also be badly splintered. Generally, "poor" timber is "utility" grade when new, as well as older material that now has loose knots, or holes where the knots have fallen out. Poor timber may also have many checks, shakes, and splits. These features are illustrated in Fig. B-1. The concrete sidewalk slab and curb sections usually contain minimum or no reinforcing. These sections should be inspected for any significant cracking, which could impair their intended use.

Table B-1
CLOSURE MATERIALS

Steel doors	* Filled sandbags
Wood doors (solid)	* Filled paper bags
Toilet doors and partitions	* Filled paper boxes
Tree trunks and limbs	* Filled plastic garbage cans
Steel cover plates	Brick or concrete block
Desk and table tops	* Filled oil or paper drums
Railroad ties	Broken concrete
Plywood	
Concrete slabs (sidewalks, etc.)	*filled with sand or earth
Wood, steel, or concrete fence posts	
Telephone or power poles	

Expedient Shelters

Openings that require closure in expedient shelters may be quite different in size and shape from those encountered in existing structures. The closures used may be the same as those employed for existing shelters, or their configuration may need to be different in order to accommodate various types of expediently constructed entry structures and openings.

This section of the appendix will illustrate several methods of fabricating expedient shelter closures.

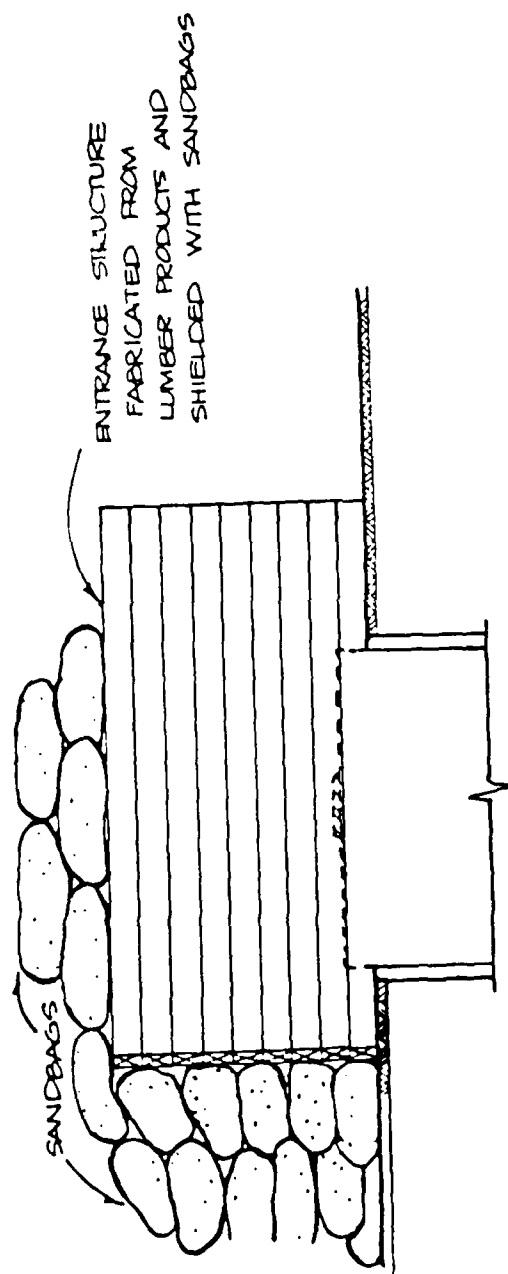


Fig. B-7. Radiation Protected Entrance Structure to Below Ground Shelters.

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B-12

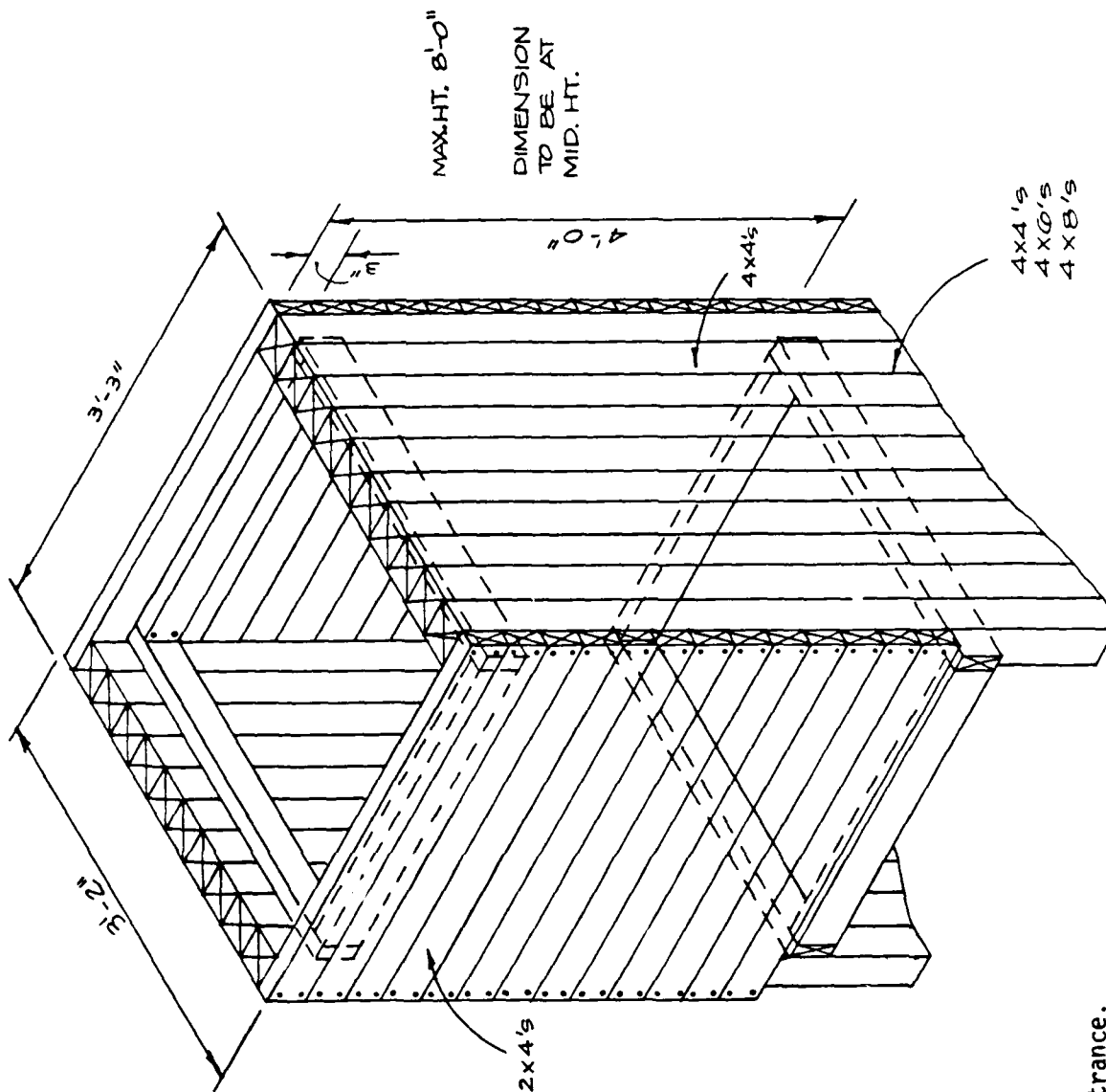


Fig. B-8. Shelter Entrance.

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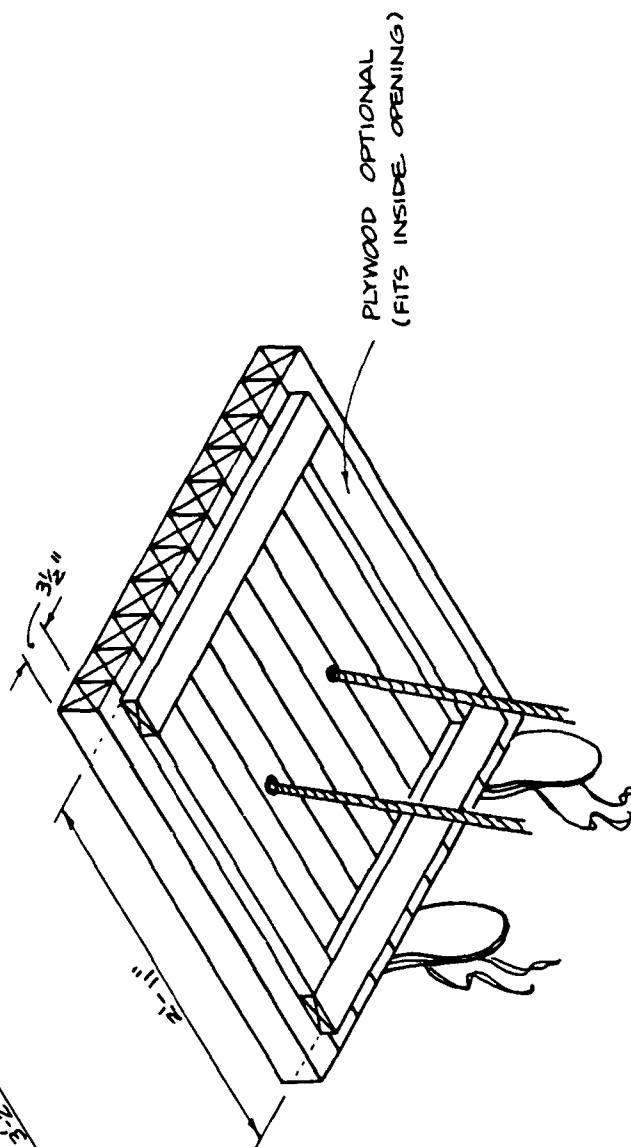
B-13

NAIL A COUPLE OF SHOES ON AS HINGES

11 - 4 x 4's

3' - 3"

3' - 2"

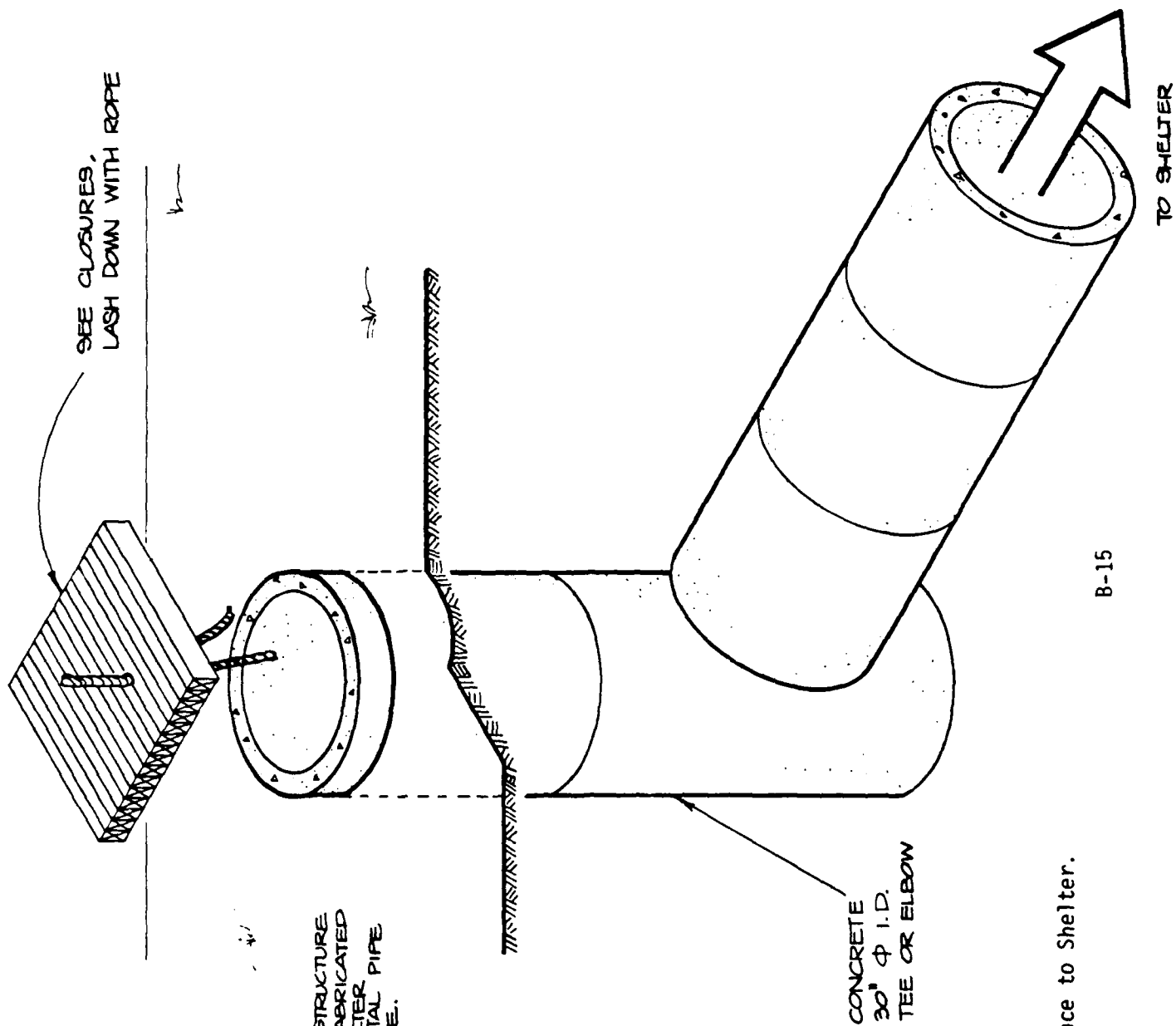


PLYWOOD OPTIONAL
(FITS INSIDE OPENING)

Fig. B-9. Shelter Door.

Addition - 5/81

B-14



NOTE: THIS ENTRANCE STRUCTURE
MAY ALSO BE FABRICATED
OF 30 IN. DIAMETER
CORRUGATED METAL PIPE
AS AN ALTERNATE.

SEE CLOSURES,
LASH DOWN WITH ROPE

B-15

Fig. B-10. Entrance to Shelter.

Addition - 5/81

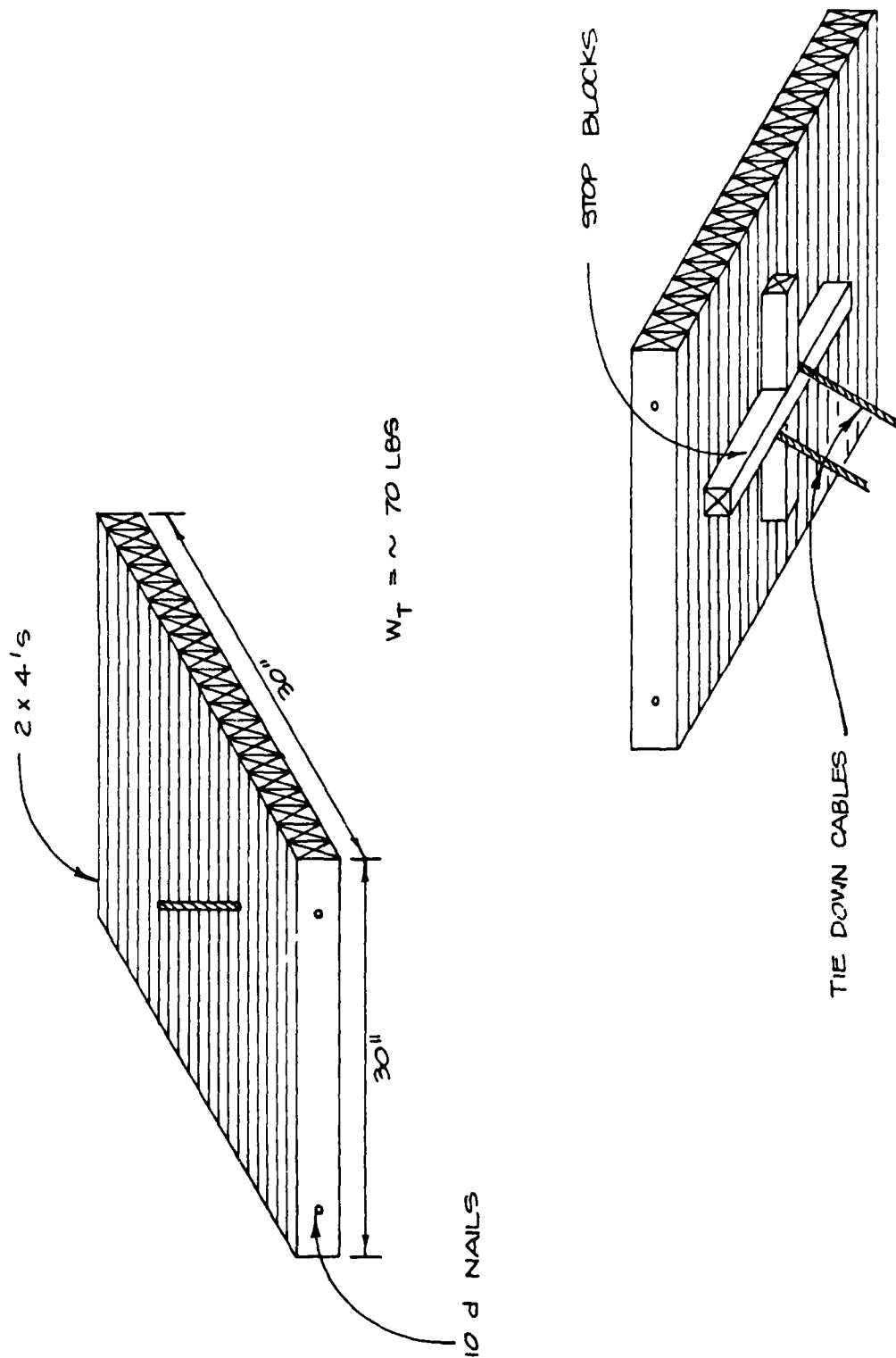


Fig. B-11. Expedient Manhole Closure, Host Area.

Addition - 5/81

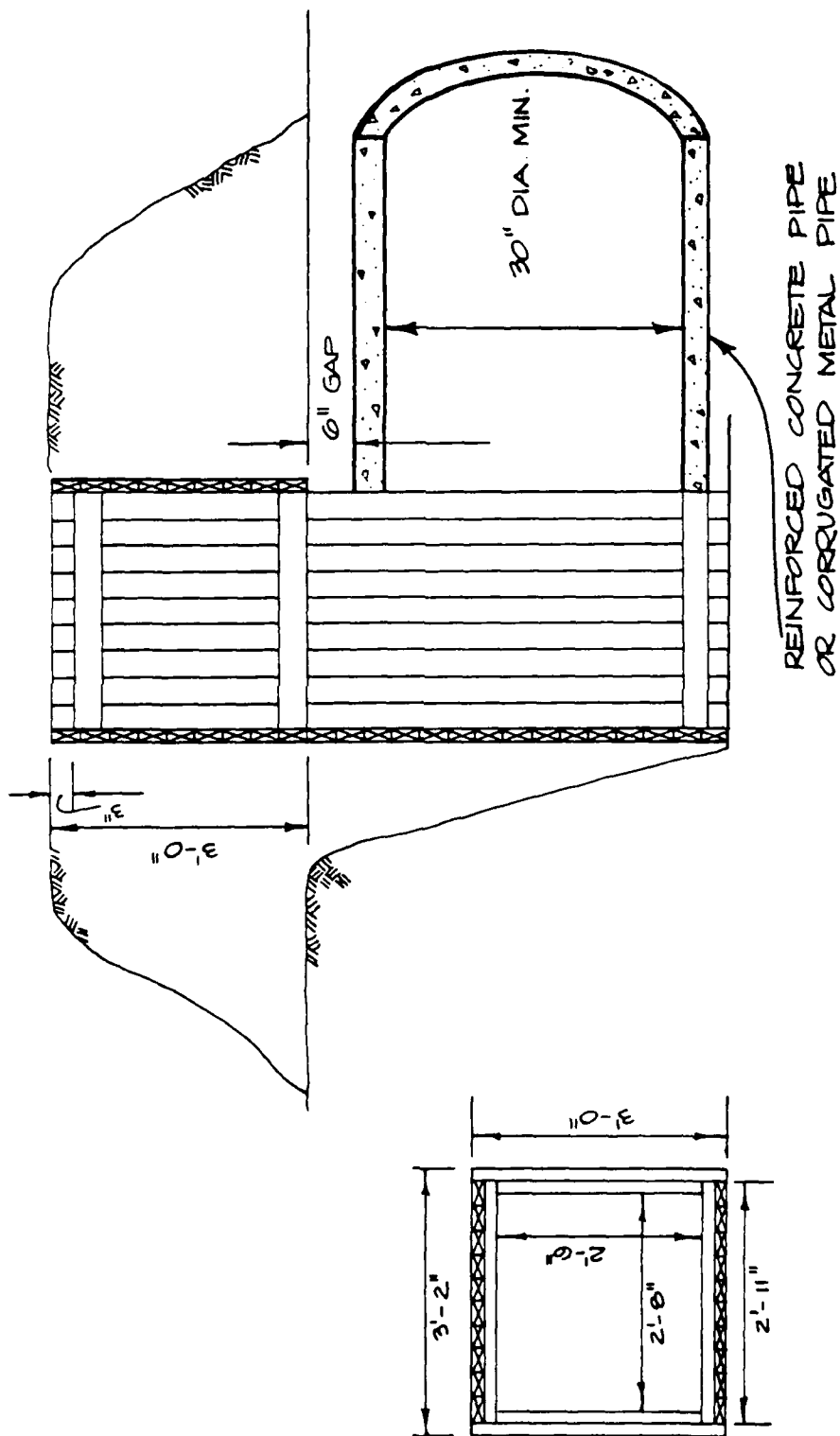


Fig. B-12. Typical Entryway to Buried Shelter With Culvert Shown.

Addition - 5/81

B-17

APPENDIX D
EXPEDIENT SHELTER OPTIONS

Appendix D
EXPEDIENT SHELTER OPTIONS

Owing to a limited number of existing structures in some of the designated Host Areas, it will be necessary to use expedient shelters. There is a wide variety of options that should be considered, including adapting facilities such as tanks, storm drains, utility vaults, or alternatively, obtaining a semi-portable structure that can be used as a buried shelter. Since many of these shelter options are large and require mechanical means to move and/or bury, or may be available only at or through local industry, a cooperative effort may be required with industrial plants, construction firms, or local civic authorities in order to render these options viable.

Table D-1 lists options that may be implemented without upgrading, and Table D-2 lists options that require some form of upgrading. Expedient shelter options discussed and data presented are as follows:

Buried tanks	page D-4
Railroad cars	page D-5 to D-8
Storm drain systems	page D-9 to D-13
Other shelter types	page D-14 to D-26

Two expedient shelter checklist summaries are provided at the end of this section for implementing expedient shelter options.

The shelter options discussed herein are only a few of the potential possibilities for Host Area shelters, and a pre-crisis survey should be conducted in order to determine the available options that would provide the best choice.

TABLE D-1: POTENTIAL HOST AREA SHELTERS

Shelter Option Description	Where to Locate, Whom to Contact
<u>Cylindrical Tanks</u>	Look in yellow pages of phone book for:
Steel tanks	(1) Tanks, Metal; (2) Tanks, Used; (3) Tanks, Fiber-
Fiberglass tanks	glass; (4) Tanks, Repairing; (5) Tank Lining and Coating.
<u>Surplus Railroad Cars</u>	Obtain from railroad equipment and supply company.
Refrigerator	For example, the Purdy Company sells surplus rail
Box cars	cars and components.
<u>Storm Drainage Facilities</u>	City and county public works departments and flood
Manholes	control districts. U.S. Geological Survey topographi-
* Large pipe culverts	cal maps and other special purpose maps (not road
* Box culverts	or street maps).
<u>Mine Shafts and Tunnels</u>	U.S. Geological Survey geologic maps, State Division
* Mine tunnels	of Mines publications.
* Rail and highway tunnels	Road and rail maps.
<u>Other Options</u>	Concrete products manufacturers in yellow pages.
Concrete utility vaults	Yellow pages under Concrete Pipe products, culverts,
Reinforced concrete pipe	manufacturers, and pipe.
Concrete tanks	Yellow pages under Tanks — Concrete.

* Box culverts and tunnels require extensive closure systems to prevent longitudinal entry of blast effects.

TABLE D-2: POTENTIAL HOST AREA SHELTERS THAT REQUIRE UPGRADING

Shelter Option Description	Where to Locate, Whom to Contact	Upgrading Method
<u>Surplus Railroad Cars</u>		
Caboose	Obtain from railroad equipment and supply company. For example, the Purdy Company sells surplus rail cars and components.	Post and beam lateral span Plywood sheathing on exterior.
Passenger		
<u>Other Options</u>		
Surplus maritime shipping containers	Container manufacturing and repair companies; Containerization International Yearbook.	Post and beam lateral span
Trailer, truck van bodies	Yellow pages under truck bodies and truck equipment and parts.	Post and beam lateral span
Metal newspaper storage bins	Look in yellow pages under Waste Paper	Post and beam lateral span

EXPEDIENT SHELTER FACT SHEET
BURIED TANKS

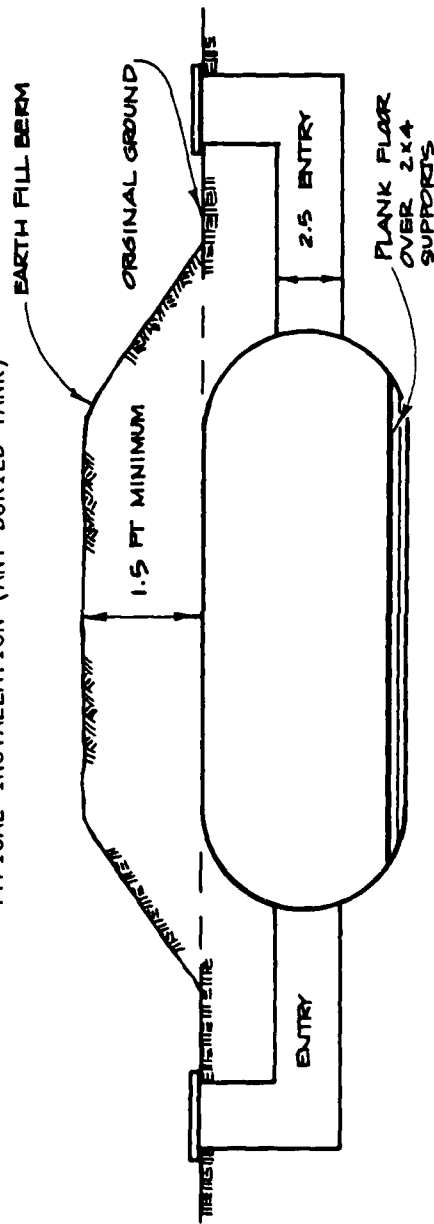
Buried tanks provide ideal shelters and, depending on their size, can be used for Host Area shelters.

- (1) Any newly manufactured, unused steel tank that is ordinarily used for underground storage.
- (2) Any other type of non-pressure new tanks, such as fiberglass fuel tanks or septic tanks, intended for burial.

Limitations: (1) Do not use tanks that have been previously used for fuel storage, toxic chemicals, or other hazardous materials.

- (2) Do not bury tanks in areas where high ground water is present, as the tanks may rise out of the ground because of fluid uplift.

TYPICAL INSTALLATION (ANY BURIED TANK)



Note: Entry can be fabricated using 30-inch diameter corrugated metal, concrete pipe, or wood framing. See Appendix B, Expedient Shelter Closures.

EXPEDIENT SHELTER FACT SHEET

RAILROAD CARS

Certain types of railroad cars can provide ideal shelter space without upgrading. Other types require minor upgrading. The railroad car options discussed are limited to those fabricated of structural steel components, as described, and would not ordinarily require upgrading:

Box cars and refrigerator cars (no upgrading)

Caboose and passenger car types require post and beam upgrading with closures on windows and other openings.

- Limitations:
- (1) All cars require their undercarriages, couplers, and miscellaneous non-essential frame materials removed.
 - (2) Refrigerator cars have access hatches on the top. Thus, the cars could be buried upright or on their sides to provide access and ventilation.
 - (3) Box cars require access holes to be cut through the sides or ends of the cars.
 - (4) Caboose and passenger cars will require closures over existing window areas to prevent damage, and all interior seating should be removed.
 - (5) Upgrading schemes are best suited to post and beam type (see Figure D-1).
 - (6) Heavy cranes or other lifting equipment are required to bury and cover cars.

Advantages of Implementing Railcars:

- (1) Railcar types suggested for expedient shelters are all constructed with steel frame exteriors. Steel or wood interiors vary with car type.
- (2) Railcar bodies are readily available from car dismantler companies.

Details of railcars buried as expedient shelters are shown on the following pages.

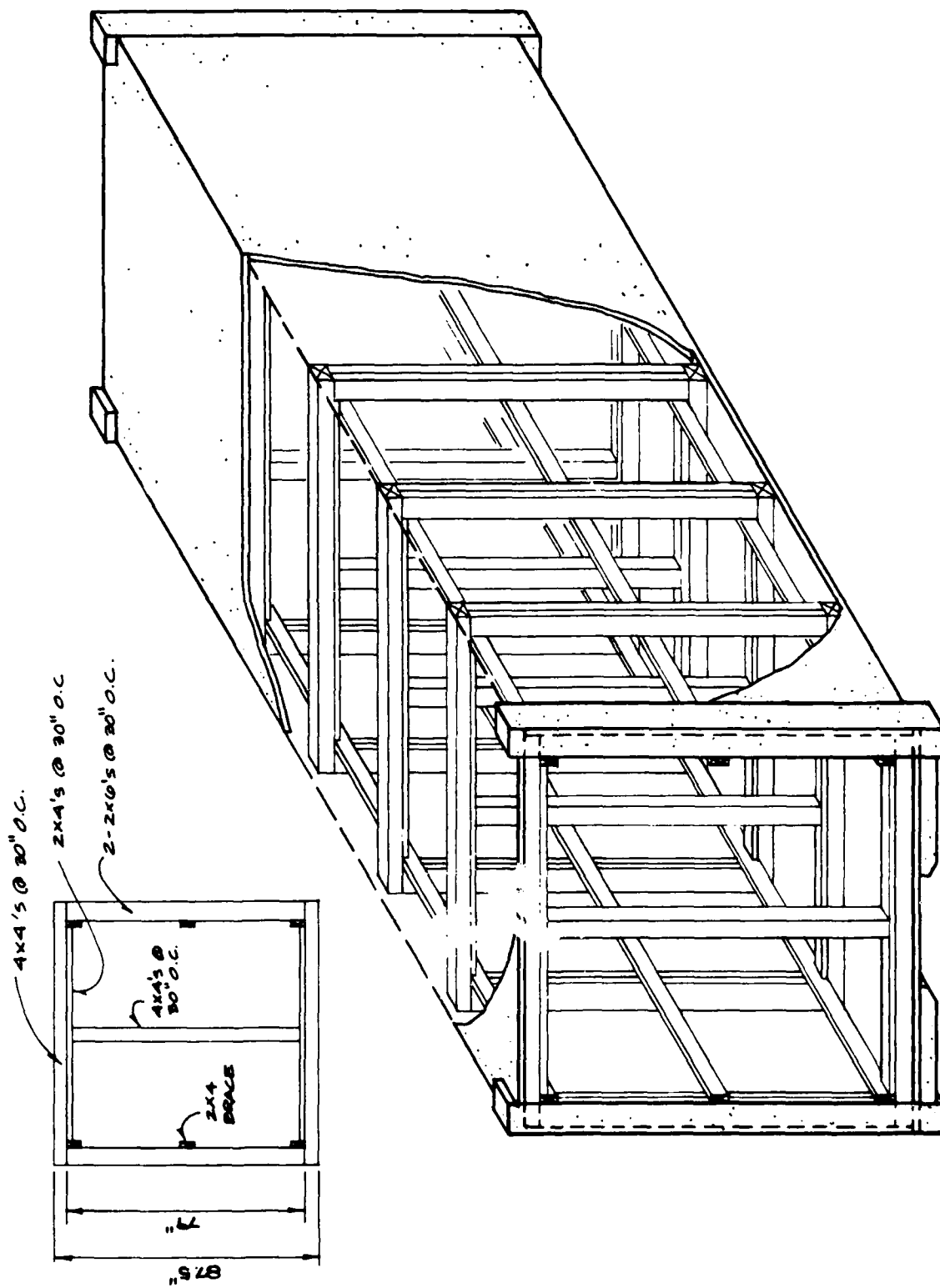
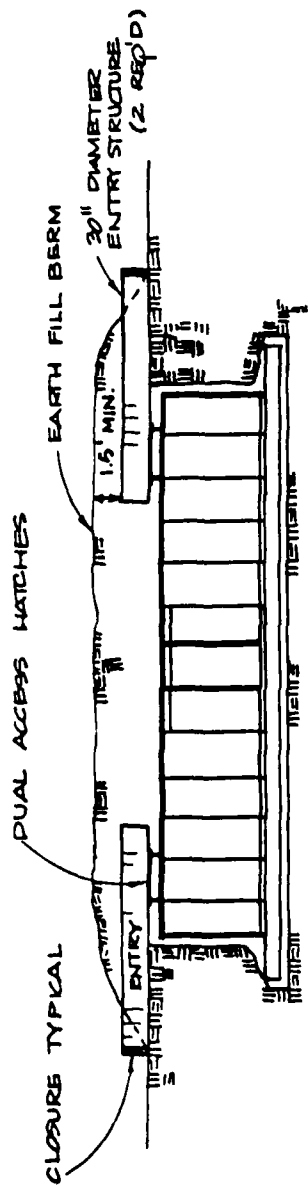


Fig. D-1. Post and Beam Shoring for Railcars, Maritime Shipping Containers, Truck Van Bodies.

Addition - 5/81

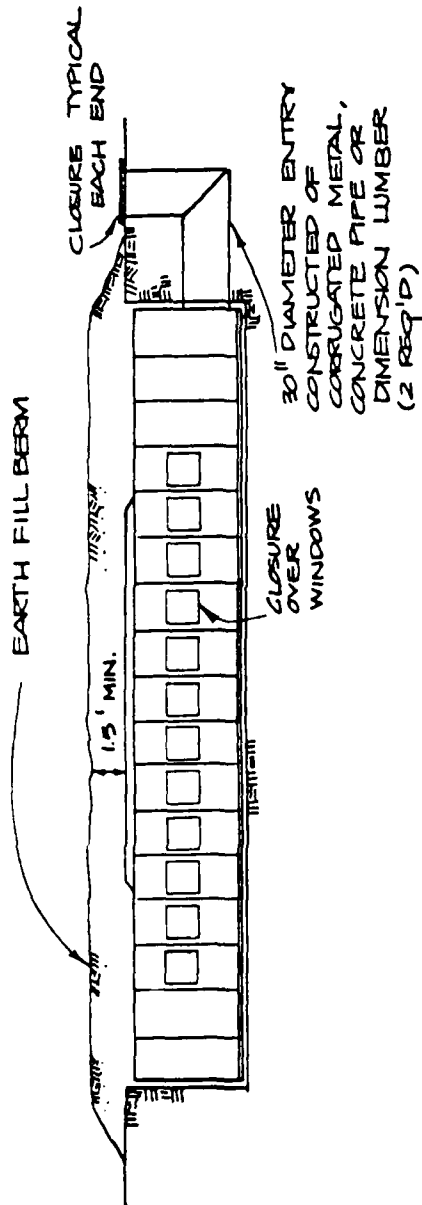
D-6

TYPICAL BURIED REFRIGERATOR OR BOX CAR



- Notes:
- (1) Railcar undercarriage and miscellaneous frame components to be removed prior to burial.
 - (2) Access to hatches to be fabricated of 30-inch metal pipe or wood framed. Double entry to compartment hatches for ventilation is recommended. Alternate entry may be provided through side of car.
 - (3) Entrance closures are required for radiation protection.
 - (4) Cars to be cleaned prior to burial.

TYPICAL BURIED PASSENGER CAR OR CABOOSE



- Notes:
- (1) Railcar undercarriage and miscellaneous frame components are removed prior to burial.
 - (2) All windows must be provided with closures, although ventilation may be expedited by modifying window space.
 - (3) Access is proposed through existing doorways at end of car.
 - (4) Entrance closures are required for radiation protection.
 - (5) Car interior to be upgraded with post and beam shoring. (see Figure D-1).

EXPEDIENT SHELTER FACT SHEET
STORM DRAINAGE SYSTEMS

Major storm drainage facilities and their components can provide long-term shelter in Host Areas. Two components of a typical system are analyzed for shelter purposes:

- o Storm drain manholes.
- o Major conduits — 5 feet and larger.

Limitations: (1) Manholes should be a minimum of 4 feet in diameter and 6 feet deep.

(2) Manholes are often located in street traffic areas and therefore, may not be available at all locations. Manholes located in street medians, parking, or non-traffic areas may be more easily implemented.

(3) Storm drainage conduits may have considerable depth of flow or be located in areas subject to tidal action, thus eliminating their availability.

(4) Large closures are necessary at conduit ends to eliminate blast effects, and these closures probably cannot be completed in less than 72 hours (see Figure D-2).

(5) Blast effects must be eliminated at all open drain inlets by sandbagging.

(6) Depth of water flow may necessitate construction of false floor systems. (See sketch of box culvert type of floor system in Figure D-3.)

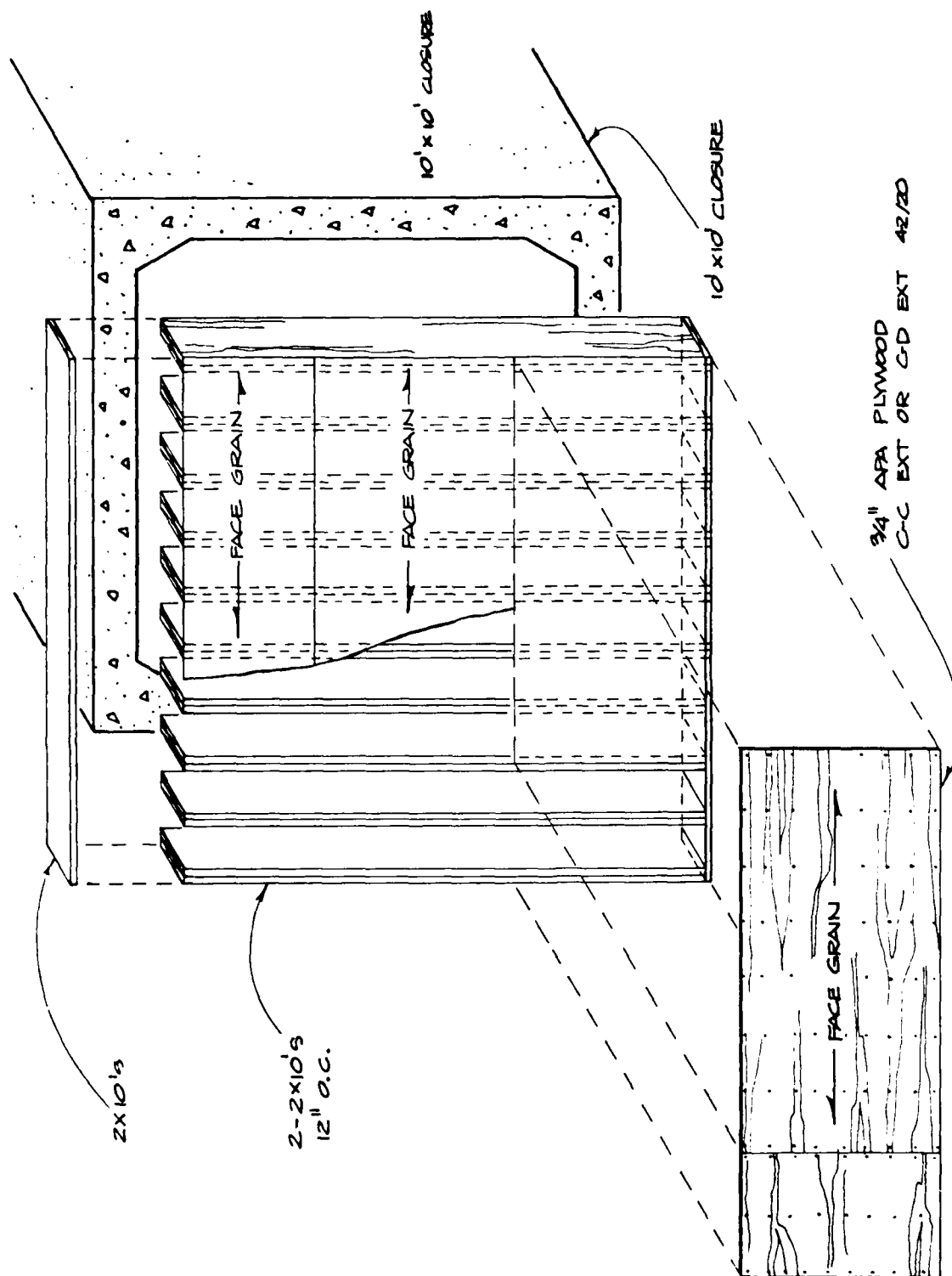


Fig. D-2. Typical Closure for a 10 ft by 10 ft Box Culvert For 2 psi.

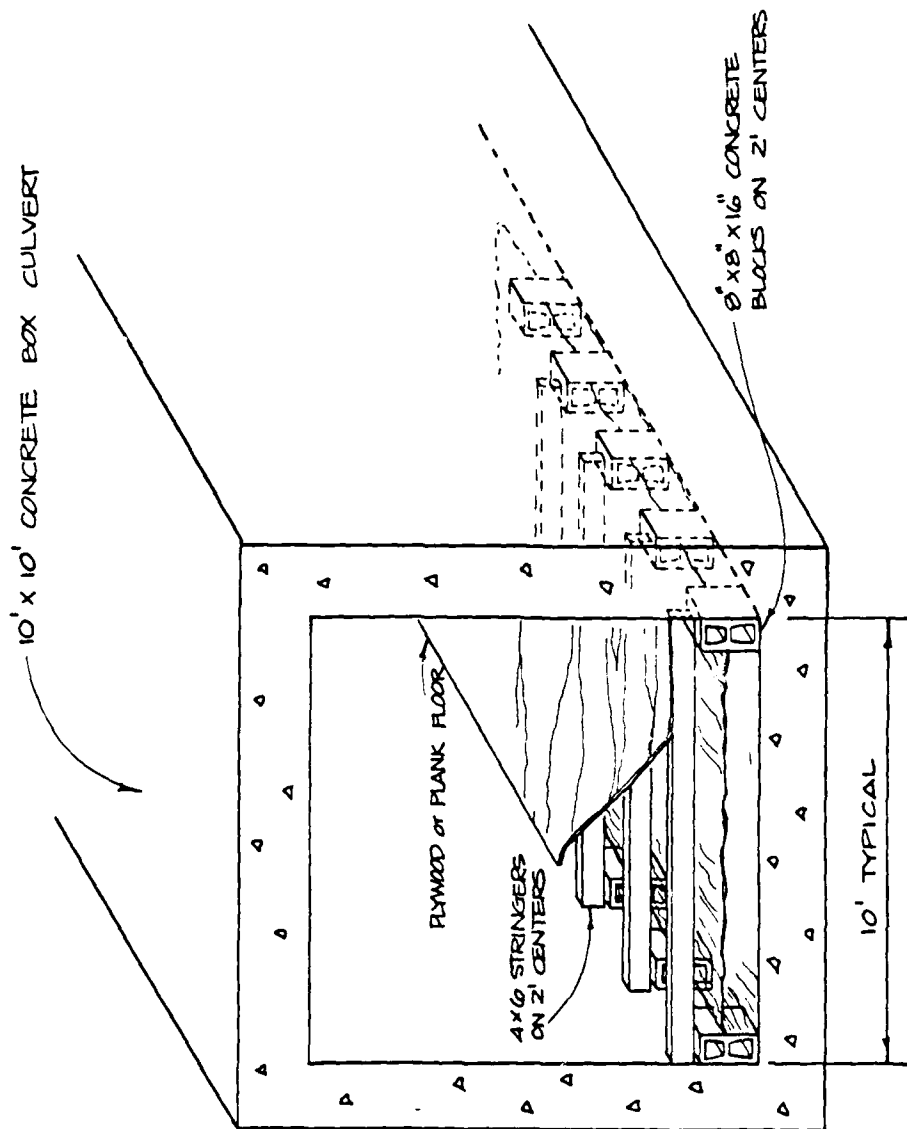


Fig. D-3. Box Culvert Host Area Shelter With Low-Flow False Floor.

Advantages of Using Storm Drain System Components as Expedient Shelters

Manholes:

- (1) Storm drain manholes are numerous. On any major drainage system they are located from 500 to 1,000 feet apart.
- (2) They require no upgrading and are easily adapted to use as one-man shelters, with addition of a temporary wood floor and modifications to manhole lid closures.
- (3) Ventilation is not required, as ventilation naturally occurs through drain pipes at base of manhole.
- (4) If storm drains are not available near the Host Area, manhole section components, as shown in Figure D-4, may be obtained from manufacturers, and one-man shelters can be buried at the Host Area site. For small industries with few employees, this may be a viable option.

Drainage Conduit Systems Greater Than 5 feet in Diameter:

- (1) Radiation or fallout shielding is generally not necessary because of depth of burial.
- (2) Ventilation equipment is not needed, as the systems have natural ventilation at all inlet locations. Fabrication of blast resistant closures with ventilation hatches must be implemented.
- (3) Drain systems are large enough to provide shelter for more than one industry.

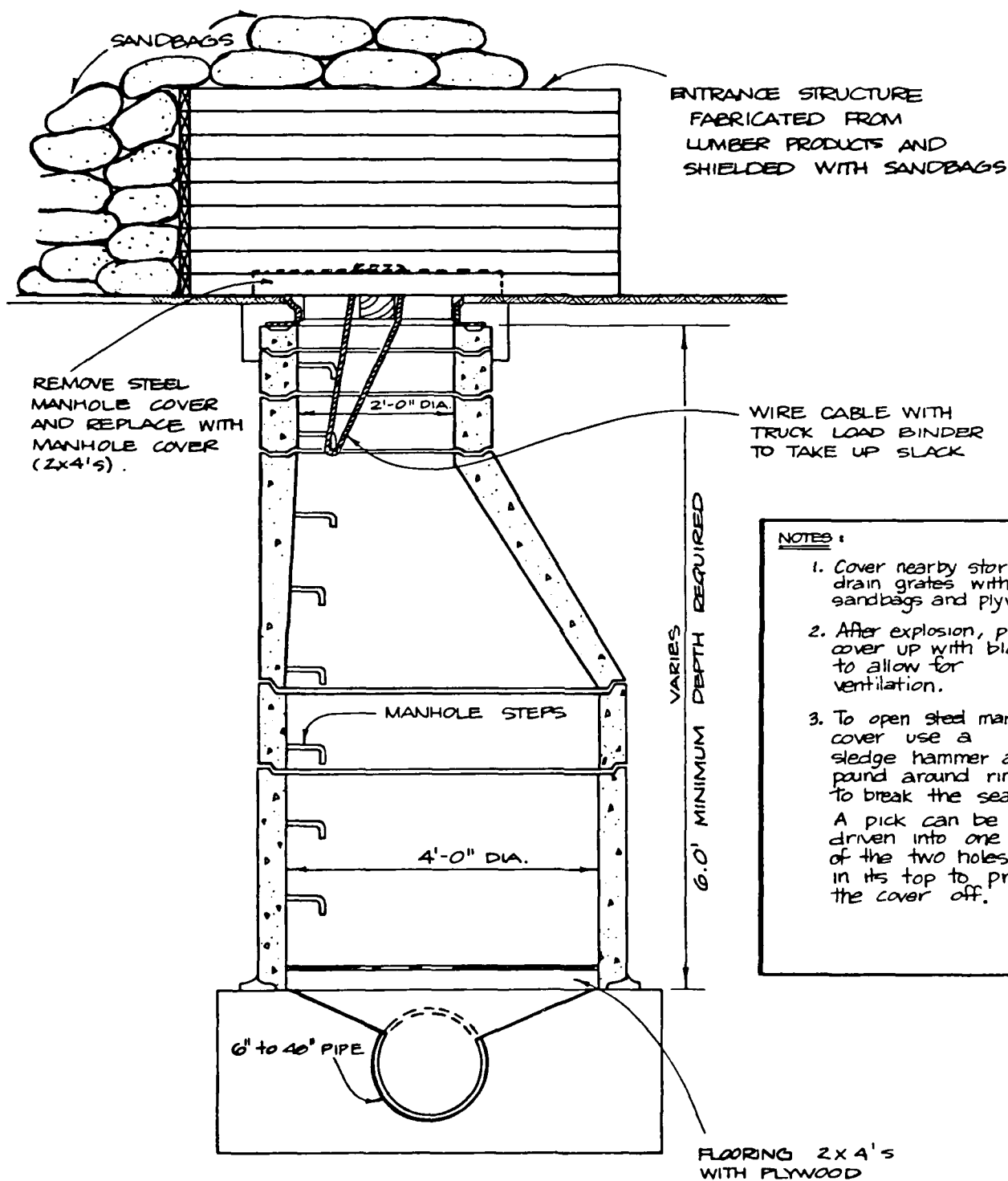


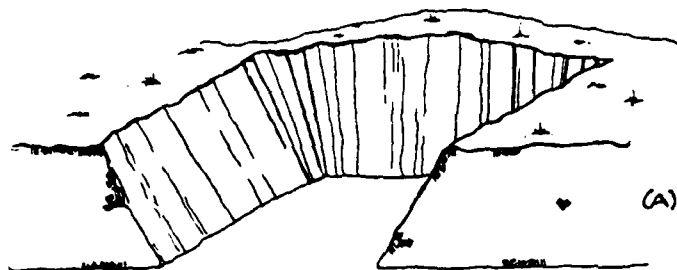
Fig. D-4. Host Area Shelter in Storm Manhole.

EXPEDIENT SHELTER FACT SHEET
CONCRETE UTILITY VAULTS

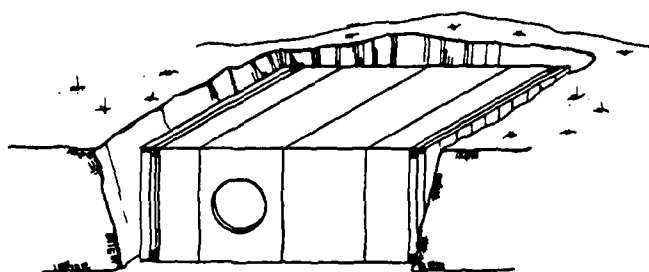
The adaptation of prefabricated underground utility vaults (the types used by telephone and electric utilities) for Host Area shelters is recommended as a valuable, practical, and easily implemented shelter option.

The implementation of precast utility vault components for a shelter has been previously tested, and placement of a six-man vault and entrance structure, including covering the vault with earth radiation protection, required less than 10 hours using three men and heavy equipment.

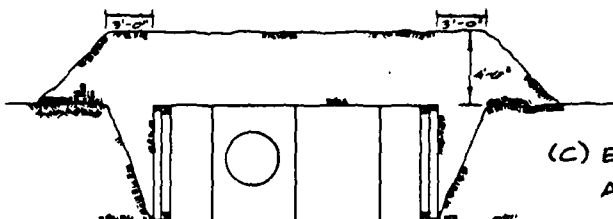
Figures D-5 and D-6 show the burial of a utility vault shelter and the various components needed to complete a shelter structure.



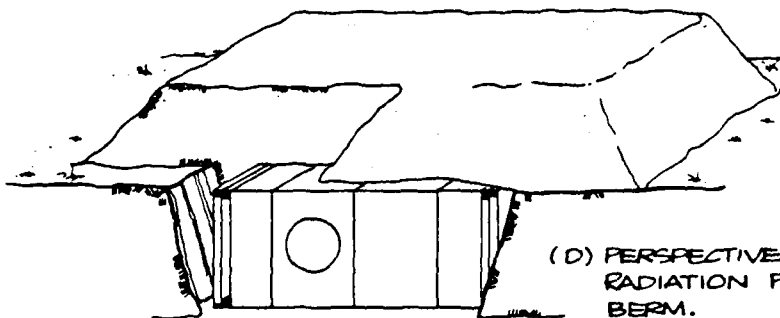
(A) EXCAVATION FOR UTILITY VAULT.



(B) VAULT IN PLACE PRIOR TO BACKFILLING.



(C) END VIEW SHOWING BACKFILL AND RADIATION PROTECTION BERM.



(D) PERSPECTIVE VIEW OF RADIATION PROTECTION BERM.

Fig. D-5. Utility Vault Shelter.

ASSEMBLY DRAWING

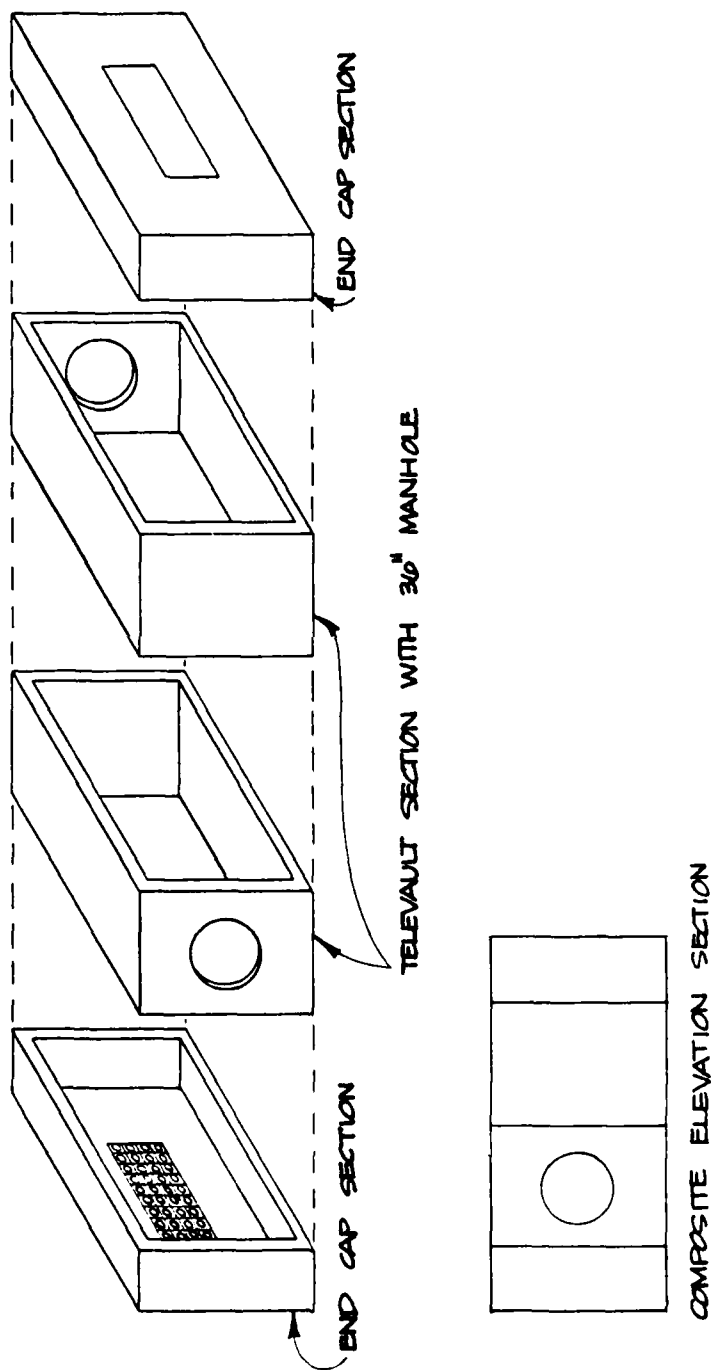


Fig. D-6. Utility Vault Shelter Components, Depicting Upgrading Methods to Provide 2 psi Overpressure Protection.

EXPEDIENT SHELTER FACT SHEET
SHIPPING CONTAINERS

Maritime shipping containers are an easily adapted option to shelter deficits in Host Areas. A wide range of container sizes, construction types, and design capabilities are available. The majority of container types are readily adaptable to Host Area shelter use.

Advantages of Using Maritime Shipping Containers for Shelter Purposes

- o A wide variety of sizes are available; standard sizes are:
 - 8 ft x 8 ft x 20 ft
 - 8 ft x 8 ft x 40 ft
 - 8 ft x 8 ft 6 in. x 35 ft
 - 8 ft x 8 ft 6 in. x 40 ft
- o Construction materials are steel, stainless steel, glass fiber reinforced plywood (FRP), and aluminum. The containers are generally designed for dry freight and some are insulated; however, refrigerator units amount to approximately 7% of the total number (Figure D-7).
- o The maritime industry has standardized construction details, and certification is a prerequisite to approval for use. Component strengths are listed below. These strengths reflect only the component listed. Frame members are designed to be stacked fully loaded, nine containers high, which may provide additional resistance to loads.

<u>Container Component</u>	<u>Design Strength (psi)</u>
Roof	0.5+
Floor	26 ±
End wall	1.7±
Side wall	0.9±

- o The majority of containers are designed to be waterproof and have a life of 7 years.
- o Upgrading to 2 psi overpressure and radiation protection of 2 feet or more of earth can be provided with post and beam shoring. After nuclear blast effects are no longer a threat, the intermediate post shores may be removed.
- o Containers are readily available from manufacturers, repair companies, and firms that deal exclusively in surplus containers.
- o They are designed to be adapted to a variety of cargo handling and transportation equipment. Empty 20-foot containers weigh approximately 4,300 lb; 40-foot containers, 7,500 lb. (Figure D-8).
- o Prior to the crises envisioned in a nuclear war, the containers may be used for secure locked storage of shelter resources and supplies.
- o They are easily transported to the site by truck and trailer.

Limitations:

- o The containers are available at nearly every major port facility city, but not nationwide.
- o Demand for used containers is high, because of their storage capabilities and versatility.

Maritime shipping containers, when properly implemented, could be a valuable option to shelter deficits. The inherent structural strength of the floor systems indicates that containers may possibly survive blast pressures in excess of 20 psi if buried upside down with proper shoring. Full-scale field tests are recommended to determine ultimate capability.

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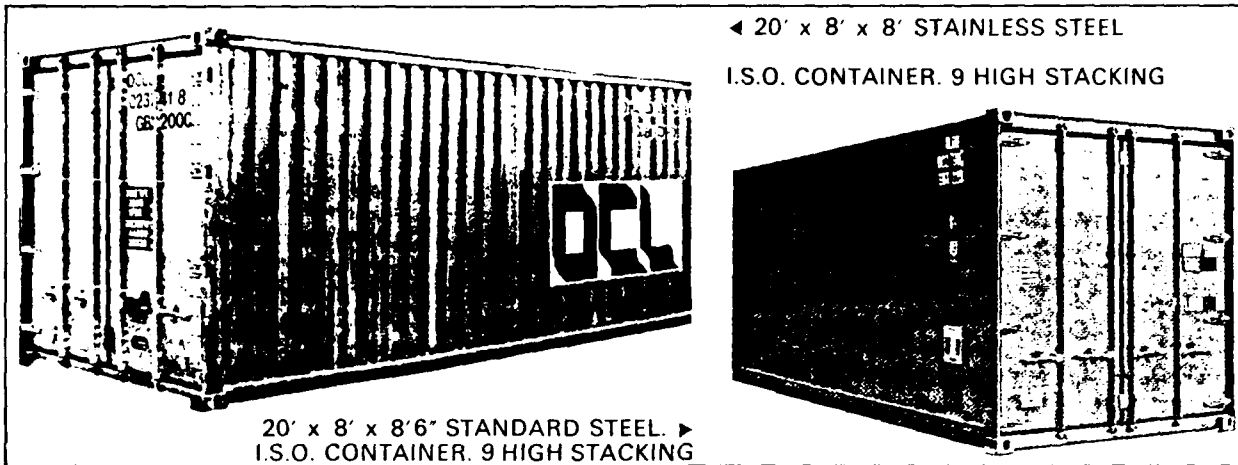
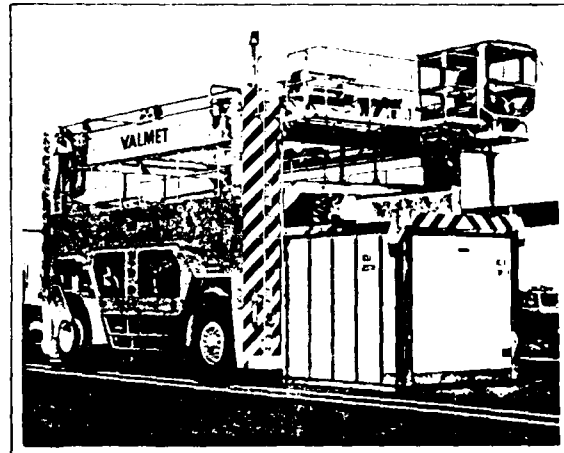
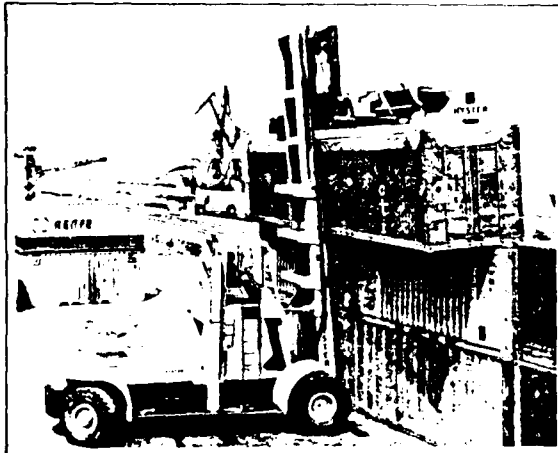


Fig. D-1. Typical Maritime Shipping Containers.



Typical Interior Details.

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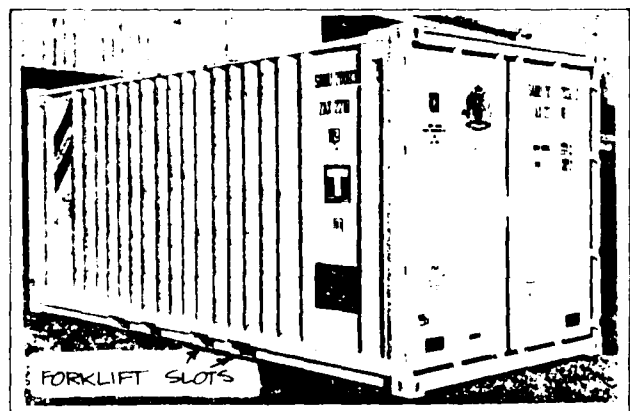
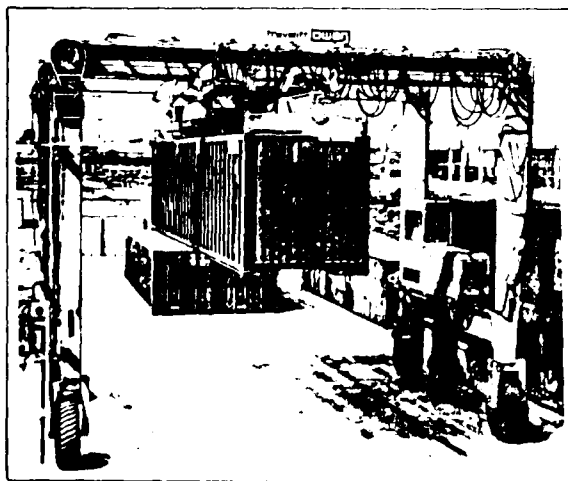


Fig. D-8. Typical Lifting Methods.

EXPEDIENT SHELTER FACT SHEET

TRUCK VAN BODIES

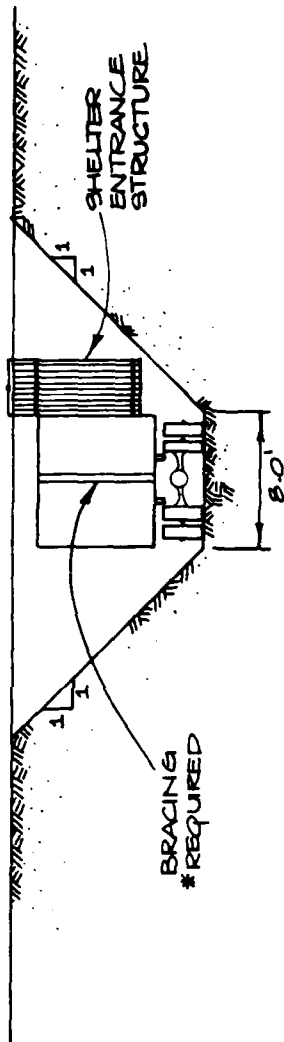
Another resource option for Host Area shelters are truck van bodies. A sketch showing a truck van body as a buried shelter is presented in Figure D-9.

Advantages of Using Truck Van Bodies for Host Area Shelter Purposes:

- o A wide variety of sizes are available.
- o Construction materials are steel, stainless steel, and aluminum.
- o They are waterproof.
- o Upgrading to 2 psi overpressure and radiation protection may be provided with post and beam construction (Figure D-1).
- o They are readily available throughout the United States.
- o They are integral with trailer frame and chassis, ready to be moved.
- o They are designed for a variety of uses.
- o They may be used for secure locked storage for shelter supplies and resources.

Limitations to Truck Van Bodies as Host Area Shelters

- o They are constructed integral with trailer frame and wheels, and thus reduce the inventory of available transportation resources in the crisis period.
- o Without the trailer floor, structural integrity is basically eliminated, and thus, they would require significant effort and resources to re-establish equivalent capability as a shelter option.
- o Demand for trailer van bodies is high, and they consequently would be a more costly alternative to other options.



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EXPEDIENT SHELTER FACT SHEET

OTHER OPTIONS

There are a number of other options to provide Host Area shelters. These options may not be the most desirable from a long stay-time criterion, but they do provide adequate radiation protection.

TRENCH SHELTERS

Figure D-10 describes a typical trench shelter. Its implementation requires only mechanical excavation equipment, sufficient planks or other resources for support of the mounded earth, and soil strata that will stand vertical to a depth of 6 feet, with no ground water at that excavated depth.

FABRICATED MANHOLES

Figure D-11 describes in some detail a shelter fabricated from readily available reinforced concrete and corrugated metal pipe. The construction of such a shelter requires only a backhoe for excavation and backfill. The expedient manhole cover should have an entrance structure similar to the one shown in Figure D-4, including sandbag radiation protection.

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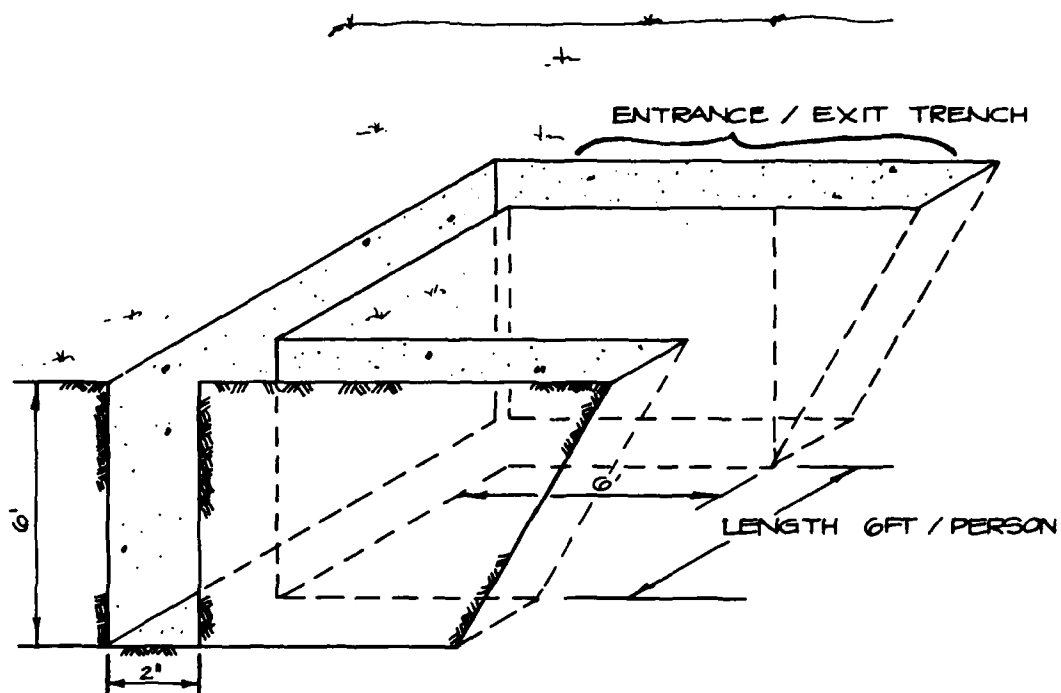
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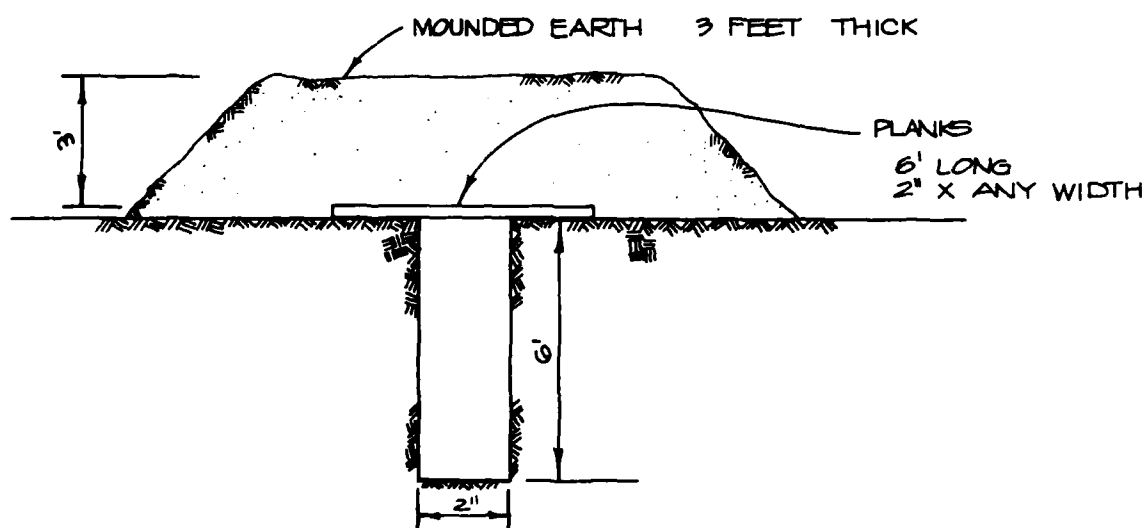
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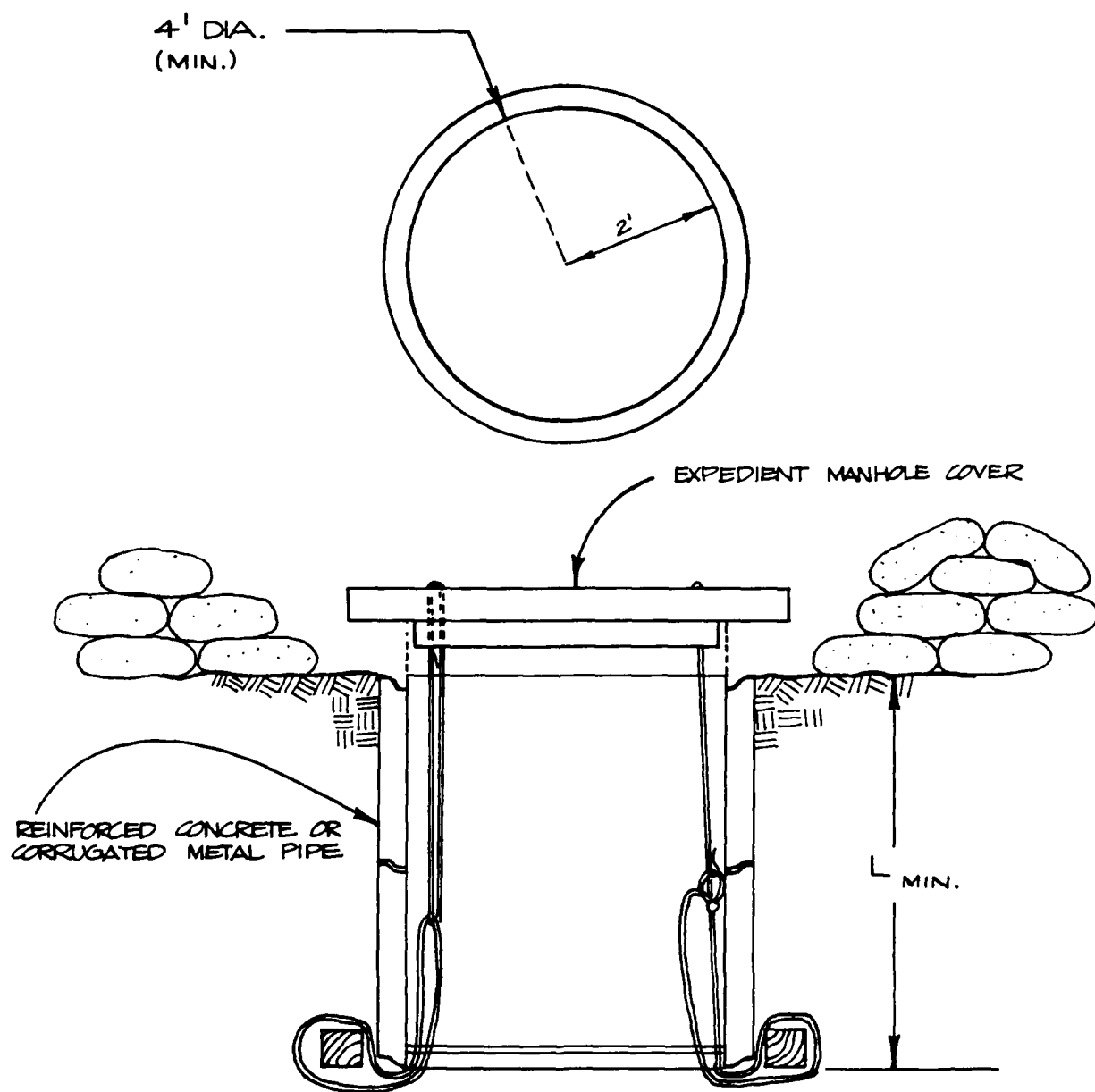
TRENCH SHELTER PRIOR TO PLACING PLANKS AND MOUNDED EARTH



SIZE TRENCH FOR NO. OF PEOPLE - 6 LIN. FEET / PERSON

- NOTES:**
1. Place planks.
 2. Place newspaper, plastic sheets, etc. to keep dirt from falling through cracks.
 3. Place 3 ft. of dirt over planks.

Fig. D-10. Expedient Host Area Trench Shelter.



4' DIA. - 1 MAN SHELTER ($L_{MIN} = 6'-0"$)
 5' DIA. - 2 MAN SHELTER ($L_{MIN} = 7'-0"$)
 6' DIA. - 3 MAN SHELTER ($L_{MIN} = 7'-0"$)

7' DIA. - 4 MAN SHELTER ($L_{MIN} = 7'-0"$)
 8' DIA. - 5 MAN SHELTER ($L_{MIN} = 6'-6"$)

Fig. D-11. Fabricated Manhole Type Shelter.

SUMMARY

The development of radiation protected Host Area shelters has been prestated in this section. Many approaches to shelter selection and upgrading have been discussed. The selection, implementation, and upgrading of the shelters discussed herein have been summarized on the following three pages:

Checklist A provides a summary of shelter selection options.

Checklist B provides a chronological sequence for burial of an expedient shelter.

Table D-3 provides an estimate of man-hours that may be necessary to implement burial, upgrading, and stocking for the majority of options discussed.

Resource lists to assist in upgrading are included for stud wall and post and beam upgrading alternatives.

TABLE D-3: EXPEDIENT HOST AREA SHELTER PREPARATION TIME

Expedient Shelter Option	Underground Burial	Access/Ventilation Floor Construction	Shelter Supplies
<u>Railroad Cars:</u>			
Refrigerator	3 men, 16 hrs	3 men, 24 hrs	2 men, 10 hrs
Box Cars	3 men, 16 hrs	3 men, 30 hrs	2 men, 10 hrs
Caboose	3 men, 12 hrs	3 men, 20 hrs	2 men, 10 hrs
+ (upgrading)	2 men, 20 hrs		
Passenger Cars	4 men, 20 hrs	3 men, 30 hrs	2 men, 10 hrs
+ (upgrading)	3 men, 8 hrs		
<u>Storm Drainage Facilities:</u>			
Manholes	N/A	1 man, 8 hrs	1 man, 8 hrs
Large Pipes	(Closures) 4 men, 20 hrs	4 men, 24 hrs	2 men, 10 hrs
Box Culverts	(Closures) 4 men, 30 hrs	4 men, 30 hrs	2 men, 10 hrs
Maritime Shipping Containers	3 men 12 hrs + (upgrading) 1 man, 8 hrs	3 men, 20 hrs	2 men, 10 hrs
Concrete Utility Vaults	3 men, 10 hrs	3 men, 10 hrs	2 men, 10 hrs
Trailer Truck Van Bodies	3 men, 10 hrs + (upgrading) 2 men, 8 hrs	3 men, 10 hrs	2 men, 10 hrs

CHECKLIST A

EXPEDIENT SHELTER IMPLEMENTATION ANALYSIS

Number of Host Area Personnel
Needing Shelter _____

Shelter Selection Options:

1. Available basement area? _____ Is it upgradable? _____ If not, locate expedient shelter option.

2. Expedient shelter option:

(a) Existing buried structure:

Onsite _____

Adjacent off site _____

(b) New option to be buried:

Tank _____

Railcar _____

Vault _____

Container _____

Other _____

3. Transportation to site:

Easily relocated _____

Special transportation required _____

4. Type of transportation equipment needed:

(a) _____

(b) _____

5. Locked secure storage for resources and stocking _____

CHECKLIST B

EXPEDIENT SHELTER STRUCTURE IMPLEMENTATION CHECKLIST FOR BURIAL

Expedient shelter has been delivered to Host Area site for burial.

- (1) Select location for burial away from buildings that may collapse or from facilities that may inundate or damage entry or ventilation equipment.
- (2) Excavate for shelter using:
 - (a) Backhoe
 - (b) Front endloader
 - (c) Crawler tractor
 - (d) Combination of above.
- (3) Excavate for entries — Two are required.
- (4) Provide all modifications to structure for entries and ventilation, and clean structure interior.
- (5) Set structure in excavation with crane or other lift equipment.
- (6) Install entry, ventilation, and closure structures.
- (7) Install interior floor, if required.
- (8) Provide all large shelter stock items prior to backfilling.
- (9) Backfill and berm structure; excavate waste disposal area.
- (10) Finish stocking shelter, if required.

STUD WALL

RESOURCE LIST

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Timber (Studs & Plates)	_____	_____
2. Bracing Material (Plywood Sheeting or nom. 1-in. Timber)	_____	_____
3. Nails	_____	_____
4. Hammer	_____	_____
5. Saw	_____	_____
6. Wedges	_____	_____
7. Tape measure/yardstick, etc.	_____	_____
8. _____	_____	_____
9. _____	_____	_____
10. _____	_____	_____

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RESOURCE LIST

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Posts, steel or wood	_____	_____
2. Beams, steel	_____	_____
3. Nails	_____	_____
4. Hammer	_____	_____
5. Saw	_____	_____
6. Wedges	_____	_____
7. Tape measure/yardstick, etc.	_____	_____
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The revisions included here are based on a testing program and are generally in the area of modified survival ratings. Additional new material on expedient shelters is included in an appendix.

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